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The Pennsylvania State University

The Graduate School

Department of Civil Engineering

Construction of Elevated Sand Mound Systems for Renovation of Treatment Tank Effluent

A Report in

Civil Engineering

by

James S. Stirling

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Engineering

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ABSTRACT

This report presents methodology for site evaluation, design, construction, operation, and maintenance of elevated sand mound sewage disposal systems. It is intended to improve builder expertise in this field so that the unacceptably high failure rate which has been experienced with elevated sand mound systems in the past can be reduced.

An extensive literature review was conducted in order to obtain information concerning on-site sewage disposal in general and elevated sand mounds in Pennsylvania in particular. The literature review revealed that there have been conflicting reports regarding the rate of failure of elevated sand mound systems in various states. The common thread revealed in the literature review was that faulty construction has, in many cases, led to hydraulic failure of elevated sand mound systems.

The writer has developed a series of recommended construction practices. Checklists address pre-construction planning and builder quality control. Design tables and worksheets are provided to enable rapid design of an elevated sand mound system for a single family residence. Finally, a maintenance and operation fact sheet is provided for use by the homeowner.

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CHAPTER 1

INTRODUCTION

The Need For Alternative Wastewater Disposal Systems

Land development is limited by the availability of the utilities necessary to serve the site. The basic utilities needed are water, sewer and electrical service.

Electrical service can be obtained at relatively low cost in virtually all areas suited for residential development. Rural electrification programs sponsored by the federal government have effectively removed the availability of electrical service from the list of limiting factors described above. Water service can be obtained through community systems or from on-site wells which draw from ground water aquifers.

Assuming that water is available, it is apparent then that a system of household wastewater disposal is the remaining critical factor which limits the development of land for residential use. The Pennsylvania Sewage Facilities Act of 1966 (19) requires all municipalities to develop a sewage disposal plan which defines areas which are served by community sewage disposal systems, areas in which new sewers will be constructed to serve future development, and areas which have been approved for individual on-site sewage systems (13, 19, 31). Developers and other persons who are purchasing lots for

residential development should be familiar with the local plan before proceeding with any land purchase. In addition, if the lot is being considered for an individual on-site wastewater system, the buyer should be aware of the requirement for field testing and inspection by the Sewage Enforcement Officer (SEO). The results of percolation tests and other inspections conducted by the SEO should be known, and the permit should be in-hand before the land is purchased.

Community Wastewater Systems

The most desirable method of residential wastewater disposal is through connection to an existing community sewer system. Unfortunately, these systems usually are located in densely populated areas, and therefore, do not provide service to rural residences. In addition, many of the existing public systems are overloaded and are unable to expand to serve new developments in fringe areas. Sewer bans have been imposed in some areas of the country as a means of limiting development until sufficient treatment capacity can be provided by the local municipality. In most cases, the decision to impose a sewer ban is a necessary step for protection of the environment and for compliance with government regulations designed to prevent pollution of surface waters. In any event, the lack of availability of a public community sewer system severely restricts growth in the community.

In some cases, it may be possible for the developer to

install a small community system designed to serve a proposed residential development. Although it is technically feasible to install such a system, there are several negative factors which limit the use of this alternative.

Maintenance costs associated with small community wastewater systems can be extremely high, particularly if they are not professionally managed and operated. Many municipalities will refuse to accept such systems if they are offered for dedication by the developer, simply because they are unwilling to accept the burden of operation and maintenance costs. In the absence of municipal operation of the system, communities often are forced to establish homeowners associations in order to finance the private operation of the system.

Cost is a key factor which limits construction of small community systems or connection to distant interceptor lines for existing systems. The cost of providing community wastewater disposal systems can exceed $10,000 per home. A recent project undertaken in Prince George's County, Maryland resulted in the expenditure of $660,000 of Community Development Block Grant funds to provide sewage service to 60 homes (18). The high cost of this project serves to highlight two important considerations. First, the high cost of providing sewage service to a residential lot severely limits the marketability of the property and may, in fact, preclude development of the land. Second, as can be seen in the example described above, local municipalities cannot afford

to permit installation of systems which have a high probability of failure, since the cost of bailing out property owners at some future date is intolerably high.

Individual On-Site Wastewater Systems

Individual on-site wastewater systems must be considered in cases in which a community system is not available. There are numerous types of systems available, but many of them are either not accepted by regulatory agencies or are too costly to warrant serious consideration for use on a residential building site. Several of the most commonly used on-site wastewater disposal methods are discussed below:

Conventional Septic Tank Soil Absorption Systems.

The first alternative to be considered for disposal of residential wastewater is the conventional septic tank soil absorption system. Septic tanks are relatively inexpensive and require very little maintenance if they are used properly. The conventional septic tank soil absorption system is an environmentally sound means of household wastewater disposal which has been used throughout the country for many years. It is unfortunate that the conventional septic tank soil absorption system has attained such a poor reputation in the eyes of many home buyers and lenders. Undesirable features include failures due to improper maintenance of the system by the owner, improper construction by the builder, or installation in soils which are unsuitable for underground disposal of sewage effluent (2, 3).

Conventional septic tank soil absorption systems can be

considered if there is no possibility to connect to a community system and if the site is suitable for underground disposal of sewage effluent. The suitability of soils for conventional septic tank soil absorption systems usually is determined by means of a percolation test administered by the local authority responsible for enforcement of the applicable health or environmental regulations. In the Commonwealth of Pennsylvania, Sewage Enforcement Officers perform this function. If the site proves to be unsuitable for installation of such a system, the residential developer must examine some of the innovative alternative systems which have been developed over the past several decades. This issue has been addressed in many areas throughout the country. In the words of the Prince George's County Executive:

> "One thing is clear, if it is not cost effective to build sewer lines or to use normal septic tank systems, then we have to consider alternative technologies and we have to find a way to pay for them." (18)

Alternative Systems. Alternatives to the conventional septic tank soil absorption system include package treatment plants which employ various treatment processes, elevated sand mounds, evapotranspiration beds, and many others. It is beyond the scope of this study to list all of the innovative systems now in use or under evaluation. The ability of the private sector to generate new ideas for the solution of the

residential wastewater disposal problem appears to be unlimited. The three alternatives listed above appear to have been accepted as practical means for residential wastewater disposal.

(1) Package Treatment Plants. Package plants for individual residences are subject to the same limitations associated with small community systems. Initial installation is expensive and there is a need for continuous maintenance to keep the system functioning properly. These two factors often preclude the use of package plants for individual residences. Conventional septic systems, which require very little maintenance on the part of the owner, often fail through neglect of even the bare essentials such as pumping out the solids every two to three years. Given the lack of attention paid to maintenance of even the most simple sewage disposal system, it is unreasonable to assume that individual on-site package plants will be properly maintained by the owners. Service contracts could be arranged for maintenance of package treatment plants, but this would further increase the costs and would probably be ineffective unless such an arrangement was mandated as a condition for operation of the plant. It has also been suggested that management districts could be set up within a community for the purpose of operating and maintaining individual on-site systems, (16), but the costs would still remain high. It also is unlikely that such an arrangement would gain wide acceptance in any community given the current trend toward reduced regulation by government agencies.

(2) Evapotranspiration. Evapotranspiration systems have been

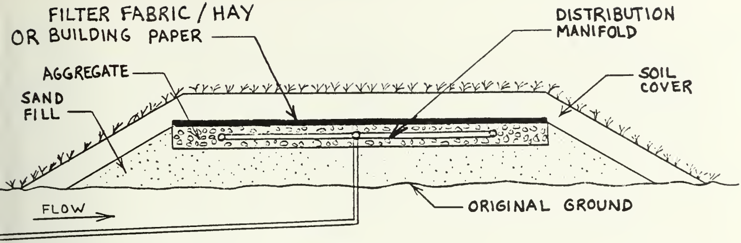
the subject of extensive research efforts and there are many workable designs in use. Evapotranspiration systems employ a treatment tank for separation of solids, followed by a mound or bed which disposes of the liquid effluent through a combination of evaporation to the atmosphere and transpiration by ground cover and plants located on and around the mound/bed. The mound or bed is installed above an impervious layer, usually a plastic material, to prevent liquid effluent from infiltrating into the ground surface and contaminating ground water supplies. Although evapotranspiration systems have been effective in warm climates, there are indications that they are not suitable for colder regions such as Pennsylvania (15).

(3) Elevated Sand Mounds. Elevated sand mound systems employ a septic tank or an aerobic treatment tank for separation of solids. The treatment tank is followed by a pressurized distribution system which distributes liquids evenly over an above ground drainage field. The liquids are renovated by percolation through the sand fill material and the natural soils located under the mound. This system works well in cases where a conventional soil absorption system cannot be used due to unsuitable soil conditions, high water table, or shallow depth to bedrock. Elevated sand mounds have been in use for over 40 years and have been tested extensively. Mound systems are more expensive than conventional soil absorption systems, but are far less expensive than most package systems or other alternative technologies. Elevated sand mounds are relatively easy to install and will function properly for many years with only minimal

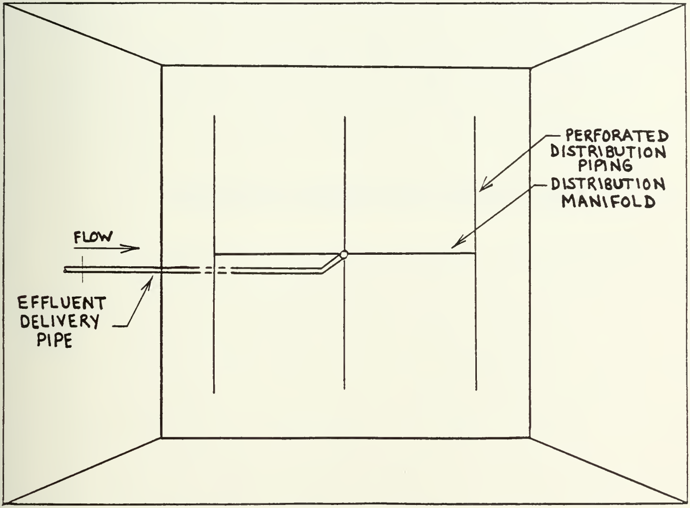
maintenance.

Figure 1.1 illustrates the basic components of the elevated sand mound system that is commonly used in Pennsylvania. The elevated sand mound is essentially an above ground, man-made, drainage field which is used to renovate treatment tank effluent. The elevated sand mound system is installed in areas in which a "limiting zone" such as a high water table, impermeable layer or bedrock is encountered near the original ground surface. The shallow depth to the limiting zone is usually the factor which precludes installation of a conventional soil absorption system.

Referring to Figure 1.1, it can be seen that the elevated sand mound consists of four basic types of fill material. The bottom layer of fill is sand. The depth of sand required varies with the depth to the limiting zone. The next layer is an aggregate material which surrounds a piping grid designed to distribute the treatment tank effluent over the entire surface area of the aggregate. This area is referred to as the "aggregate absorption area". The aggregate and the sand, as well as the natural soils from the surface to the limiting zone, serve to renovate the treatment tank effluent. The aggregate is covered by a thin layer of hay, untreated building paper, or a comercially available filter fabric. The purpose of this layer is to prevent soil particles from clogging the aggregate bed or the distribution piping. The final layer is the soil cover which surrounds all of the previously described fill. The purpose of the soil cover is to protect the aggregate



A. PROFILE VIEW



B. PLAN VIEW

Figure 1.1.
Components of a Sand Mound System

and sand fill layers from erosion and to seal the system from the outside environment. The soil cover also helps to prevent freezing of treatment tank effluent in the distribution piping in the winter months. The distribution piping embedded in the mound is a grid made of PVC piping which has been perforated at six foot intervals. A "dose" of treatment tank effluent is fed to the distibution system under pressure by a pump or by a siphon located in the dosing tank which is adjacent to the treatment tank. This process is called "pressure dosing". The individual components of the system are described in extensive detail in later chapters of this report. Construction of elevated sand mounds in Pennsylvania will be the focus of this study, as described in the remaining sections of this chapter.

Background: Elevated Sand Mound Systems

Elevated sand mound systems have been used extensively in many areas of the United States. The basic design principles have evolved from the early NODAK mounds introduced in North Dakota to the latest designs now used in Wisconsin, Pennsylvania, New York, Indiana, and most of the other states in the Great Lakes region. Mound systems also have been introduced in other areas of the country such as New Mexico and California (17) and also are in use in Canada. The current "state of the art" in sand mound sewage disposal technology originated in large part from the Small Scale Waste Management Project at the University of Wisconsin (13, 28). In addition, Purdue

University has set up a research project, similar to the one established at Wisconsin, using mound systems based largely on the Wisconsin design (33, 34).

Elevated Sand Mounds in Pennsylvania.

Approximately 13 percent of the soil area in the Commonwealth of Pennsylvania is suitable for installation of conventional soil absorption systems (6, 23). It has been estimated that of the remaining 87 percent of the soil area, 45 percent is suitable for installation of alternative on-lot sewage disposal systems, such as elevated sand mounds, and that 42 percent is not suitable for installation of any type of on-lot sewage disposal system involving soil absorption (6, 23, 32). The positive economic impact of continued growth in the residential construction industry should, therefore, dictate the enthusiastic approval of these systems by all interested parties. That has not, however, been the case in Pennsylvania.

Failure Rates: Conflicting Evaluations. Hydraulic failure of an elevated sand mound system is usually defined as the discharge of effluent to the surface of the ground. This definition, however, is very narrow and does not address other evidence indicating that a system is malfunctioning. A better definition, adopted as a policy statement by the Great Lakes - Upper Mississippi River Board of State Sanitary Engineers, is stated as follows:

"Failure of a subsurface soil absorption system

shall include, but not be limited to, the occurrence of any one, or combination of, the following factors:

1. The system refuses to accept sewage effluent at the rate of design application, resulting in interference with plumbing fixture use.
2. Sewage effluent exceeds the infiltrative capacity of the soil, resulting in objectionable odors, ponding, seepage, or other discharge of effluent to the surface of the ground or surface waters.
3. Effluent discharges from the absorption system result in contamination of a potable water supply, groundwater, or surface waters.

Conditions of malfunction caused by a rarely occurring phenomenon, which is not seasonal, and is self correcting without physical alteration of the absorption system are not considered to be failures." (1)

There has been a continuing debate concerning the effectiveness of elevated sand mound systems. Field studies have been conducted at various locations around the Great Lakes region in an attempt to evaluate the performance of elevated sand mound systems. The results of those studies were inconclusive and only served to add fuel to the debate. For example, in a 1976 study of mound systems in Erie County, New York a success rate of 88.9 percent was documented (17). In the Erie County study, 121 of 136 mounds were found to be in sound operating condition based on a

dye test designed to reveal hydraulic failure of the mound. The study also revealed that there was no statistically significant difference in the failure rates of new mounds and mounds which had been in operation for as long as 30 years. In contrast, a 1978-79 study conducted in Pennsylvania by personnel at the Institute for Research on Land and Water Resources, at The Pennsylvania State University, reported a success rate of only 57 percent (6). The Pennsylvania study was based on field sampling of 81 elevated sand mounds, most of which were less than five years old. It is interesting to note that the Pennsylvania study also included a questionnaire which was sent to 705 municipal sewage enforcement officers asking them to provide data concerning the failure rate of Pennsylvania sand mounds. Questionnaire responses were received from 361 of the 705 sewage enforcement officers. The respondents reported that only 6 to 7 percent of the 2700 systems installed in their municipalities were malfunctioning. The failure rate reported by the sewage enforcement officers was far below that which was observed in the field. The wide variation in these figures may be attributed in part to the fact that the current regulatory system employed in the Commonwealth of Pennsylvania places emphasis on inspection prior to construction of the elevated sand mound for the purpose of site suitability evaluation. Sewage Enforcement Officers generally are not encouraged by the employing municipality to actively search for failing systems which are in violation of environmental regulations. In most cases, the only time that a failing system is identified is when a complaint has been received by the local

municipality or the Pennsylvania Department of Environmental Resources. The Pennsylvania study also stated that the failure rate of mound systems appeared to be related to the age of the system, with the failure rate for older systems being much higher than that found for newer systems.

Research findings published by Purdue University indicate that pressure dosed mound systems, similar to those used in Wisconsin and Pennsylvania, have operated for the past five years without any reported failures (34).

Finally, in a speech presented at the On-Site Sewage Treatment Conference held at the Pennsylvania State University in February, 1986, Dr. J. Converse , Professor of Agricultural Engineering, University of Wisconsin and Director of the Small Scale Waste Management Project reported that the failure rate for mound systems in Wisconsin was less than three percent (32). This figure was based on annual County inspections of all mounds in the state of Wisconsin.

The conflicting results of studies such as those described above has resulted in the lack of acceptance of elevated sand mounds by some of the key parties in the residential development process. The conservative position taken by the Farmers Home Administration (FmHA) has been particularly damaging to the residential construction industry. Elevated sand mounds presently are not approved for use on homes which are financed through FmHA loan programs. Many builders avoid installation of elevated sand mounds in order to protect themselves against liability for failed systems.

Working Toward a Concensus. The conflicting results of the studies described above can be attributed to many causes. First of all, at the time the first two studies were conducted, uniformly accepted standards for design and construction of sand mound systems had not been developed. That is still the case today, but the gap is much narrower following publication of recommended standards by the Great Lakes - Upper Mississippi River Board of State Sanitary Engineers in 1980 (1). Another possible cause of the divergent results was the method of testing. The Erie County study was based on dye tests which were designed to reveal surface discharge of effluent. These tests did not necessarily reveal hydraulic failure unless the system was in serious distress and the mound was saturated at the time of the test. On the other hand, the Pennsylvania sampling involved a much more detailed evaluation of site conditions and an evaluation of the probable causes of the hydraulic failure of the mound.

There are many other variables which could help to explain the conflicting results of the studies, but the point to be made is that there will be no concensus on the effectiveness of elevated sand mounds until uniform standards for design and construction have been adopted. It also should be clear that conclusions cannot be drawn based on any single study due to the wide variations in testing methods and the definitions of "failure" used in the various studies.

The latest standards adopted by the Pennsylvania Department of Environmental Resources (19) include changes which bring the Pennsylvania design in line with the reliable

designs which have been proven in other locations. The performance of mounds constructed under the latest DER design standards has reportedly been exceptionally good (32).

The current designs for elevated sand mounds are reliable and proven through extensive use in many areas of the country. There are only minor differences between the designs recommended by the Great Lakes - Upper Mississippi River Board of State Sanitary Engineeers, the Small Scale Waste Management Project at the University of Wisconsin (28), and those recommended by the Pennsylvania Department of Environmental Resources. Continued attempts to field test proven systems appear to be wasteful. It is the opinion of this author, based on a review of field evaluations of mound systems and literature published by sanitary engineers, regulatory agencies, and research organizations, that the systems work well and do not have an unreasonably high failure rate. This sentiment was best expressed in a report presented by Mr. Gary D. Plews of the Washington State Department of Social and Health Services to the Fifth National Conference on Individual Onsite Wastewater Systems in 1978:

> "Good information is available on some innovative methods. For example, considerable performance information on mounds is now available. While some minor variation in basic mound design may be needed, the basic design is reliable and proven, and the information is available. There does not

> appear to be a need to establish more mounds for research purposes for the proven applications in most climates. To restudy the mound system design in every state would seem to be a total waste of money and manpower; yet, it is being done in several states today... Regulatory agencies should review and accept or reject, but refrain from furthering the "We must do it here" syndrome for every alternative." (17)

Rejection of elevated sand mounds by FmHA, which is in effect a regulatory agency in this matter, is difficult to understand, given the preponderance of positive evaluations of these systems.

Causes of Hydraulic Failure in Elevated Sand Mounds.

The causes of hydraulic failure of elevated sand mounds can be categorized into the following primary areas, improper: design, construction, inspection, or maintenance.

Design. The design used in Pennsylvania before the new DER standards were adopted in 1983 was based on gravity flow of effluent into a distribution box and then into the mound for distribution through a series of perforated pipe sections. Numerous hydraulic failures of these mounds were documented, many of which were caused by an uneven distribution of the effluent in the mound. The uneven distribution combined with an irregular dosing rate often resulted in formation of a

layer of crust which eventually became impermeable. Ponding within the mound was also a common occurrence which eventually resulted in compaction of the underlying fill and creation of an impermeable surface which acted as a channel for hydraulic failure of the mound (6). The design standards for elevated sand mounds were revised in 1983 to include a pressure dosing system which is designed to eliminate the problems described above. As a result, sand mounds are now fed via a pressurized system of small diameter perforated pipe. Dosing is controlled so that a measured dose is applied during each cycle of the pumping system. It is widely believed that the latest design changes have eliminated the problems described above. Conversations with builders and with DER personnel confirm that there have been no known failures of systems built in accordance with the 1983 DER standards. Additional field surveys will be required to verify the performance of these newly installed systems.

Inspection. Hydraulic failure of sand mounds also has been attributed to the improper installation approval of mound systems in areas with unsuitable soils or a high water table. The responsibility for inspection of the site and evaluation of the soil conditions lies with the Sewage Enforcement Officer. The standards for approval or rejection are established by DER and implemented by the SEO in the field. Responsibility for enforcement of the DER standards is delegated to the local municipalities. It is, therefore, absolutely essential for each municipality to employ a SEO

who is highly trained in the design and construction of on-site sewage disposal systems and who is knowledgeable concerning the local soil conditions. Strict adherence to the standards set by DER, combined with knowledge of the local soil conditions, should prevent this type of failure.

Maintenance. Improper maintenance of the mound system following installation also has resulted in hydraulic failures. Failure to pump out solids from the treatment tank on a regular basis can result in carry-over of solids into the distribution system and can lead to clogging. Failure to control erosion of the outer soil cover also can result in hydraulic failure. Mound failure also can be caused by disturbance of soils immediately adjacent to the fill area. There are numerous other maintenance related problems which could result in eventual failure of the mound, all of which should be pointed out to the owner upon completion of construction. The owner must be made aware of the environmental hazards related to failure of the system so that he will take appropriate action to correct minor problems before a serious failure occurs. Unfortunately, many owners are reluctant to report problems because of the additional expenses which will be incurred for repair or replacement of the system (23).

A fact sheet, included in Chapter 5 of this report, contains information which should be provided to the owner by the builder at the time the system is turned over. The fact sheet lists some basic operation and maintenance recommendations which, if followed, should ensure proper operation of the system

for many years. In addition, it is recommended that the builder make arrangements for a service contract designed to provide for septic tank pumping (or periodic inspection of the mechanical and electrical components of the aerobic treatment system) and inspection of the distribution system. The cost of the service contract should be included as a part of the construction cost of the system. The use of the service contract approach may also help to alleviate some of the perceived problems associated with the use of septic tanks or aerobic treatment tanks for residential wastewater disposal.

Construction. Construction related failures include such problems as improper preparation of the soil surface prior to placing fill material, compaction or smearing of the soil in and around the fill area, compaction of the fill material, crushing or improperly connecting distribution piping, and many others. These problems will be addressed in detail in this study.

Problem Statement

Failures of elevated sand mound systems in Pennsylvania have been attributed to deficiencies in design, construction, inspection, and maintenance of the systems. Construction related failures may very well be due to low levels of contractor knowledge and experience in the construction of mound systems. Given the fact that there currently is no requirement for contractor certification or specialized

training for installation of elevated sand mounds, there is a need for a concise reference publication which addresses the essential elements of the construction procedures associated with mound systems.

Objectives

The primary objective of this study is to promote the reliable construction and operation of elevated sand mounds in the Commonwealth of Pennsylvania. This objective will be met through development of a construction manual which can be used by contractors who have little or no experience in the construction of mound systems. The manual will include a step-by-step description of all phases of the construction process. The manual also will address all regulatory requirements, design standards, and maintenance procedures applicable to mound systems installed in Pennsylvania.

Organization

The first chapter of the manual includes extensive background information and a statement of the problems to be addressed in the remaining chapters. The remainder of the manual is organized as described below:

The second chapter addresses the evaluation of the site conditions in order to determine the suitability

of the site for installation of an elevated sand mound. The role of the SEO is addressed in detail and soil evaluation procedures including the percolation test, visual inspection for soil mottling, and the use of SCS Soil Surveys for site evaluation are discussed.

Chapter 3 addresses the design standards associated with elevated sand mounds constructed in Pennsylvania. Specific topics addressed include sizing of the mound and design of the pressure distribution system including all mechanical components.

The fourth chapter describes the construction procedure in detail, including recommendations for quality control and quality assurance. Specific recommendations are provided for methods, materials, and equipment. Improper construction practices which could lead to eventual failure of the mound are discussed in detail.

Chapter 5 addresses the operation and maintenance responsibilities of the owner. A fact sheet describing the operation of the system and a listing of required maintenance tasks and appropriate maintenance intervals is provided. The fact sheet should be completed by the builder and turned over to the owner upon completion of each project. The critical role played by the owner in ensuring that the system remains in proper working order is emphasized in this chapter.

The final chapter summarizes the information presented in the report and presents conclusions reached by the author based on field observation of mound construction

and review of published literature. Recommendations are made concerning areas for further research.

CHAPTER 2

SITE SUITABILITY FOR ON-LOT SEWAGE DISPOSAL

Regulatory Approaches

In response to public pressure on governments to protect surface waters and groundwater supplies from contamination by wastewater, many states have adopted strict regulations which govern the installation of on-lot sewage disposal systems. The regulatory approach varies from state to state, but the focus in almost all cases is on the initial evaluation of the suitability of the site. The site evaluation is usually a part of the permit application process prior to construction. As such, it helps to prevent the installation of systems which will fail at some future date due to unsuitable soil conditions or other limiting factors associated with the site.

State Regulations.

The level of control exercised by the government over the installation of these systems also varies widely. In West Virginia, for example, the State Department of Health requires all installers of septic tank systems to attend a training program sponsored by the Department and also requires each installer to pass a written examination in

order to obtain certification for installation of septic tank systems of any kind (16).

In Wisconsin, the focus is on those who inspect and issue permits rather than on the installer. The state requires that each site proposed for an on-lot sewage disposal system be evaluated by a "Certified Soil Tester". In order to obtain certification, these persons must attend a state sponsored training program and pass a written certification examination (16). There are no prerequisite qualifications required for Certified Soil Testers other than the training discussed above. The training program places strong emphasis on soils analysis. Personnel from the U.S. Department of Agriculture, Soil Conservation Service have been employed to assist in the training program (16).

The approach employed by the Commonwealth of Pennsylvania is similar to that taken by Wisconsin. The evaluation of site suitability is the responsibility of a Sewage Enforcement Officer (SEO). As in the case of Wisconsin, there is no prerequisite qualification for employment as a SEO. Each individual must pass a written certification examination. Attendance at DER sponsored training sessions is encouraged, but not required. The training program addresses the administrative responsibilities of the SEO and the technical functions of site evaluation, system design, and construction inspection. Certification must be renewed at two year intervals and the SEO's must complete continuing education requirements to maintain certification.

The regulations in force in Pennsylvania place a strong emphasis on prevention of sewage system failures through evaluation of the site conditions as a part of the permit approval process. In a speech before the First National Conference on Individual On-Site Wastewater Systems, sponsored by the National Sanitation Foundation in 1974, W.D. Middendorf, Director, Bureau of Community Environmental Control, Pennsylvania Department of Environmental Resources, described the focus of the regulatory approach as follows:

> " The types of systems that are used and provided for in the regulations are correlated with soil types. We rely not so much on the percolation test, though it is still used, but rather we rely very heavily on the soil profile itself. Therefore, it is mandated that for every lot...soil profiles must be done down to a depth of seven feet or until you hit a limiting zone such as the seasonal high water table or bedrock." (16).

The Need for Effective Control.

There is an obvious need for effective control of the installation of on-lot sewage disposal systems in order to prevent pollution of ground and surface waters. It also is important, however, to recognize the economic impact of ineffective controls. The "bad name" associated with on-lot

sewage disposal systems has been attained in large part because of ineffective control by Sewage Enforcement Officers as well as ineffective quality control by installers. These problems will have to be resolved in order to obtain widespread acceptance of these sytems by lenders who finance residential construction projects and by mortgage bankers. The position taken by the Farmers Home Administration (FmHA) at the First National Conference on Individual On-Site Sewage Disposal Systems (16) is indicative of the dissatisfaction with the level of control practiced at that time. Although there have been significant improvements made in inspection and quality control practices, along with a number of technological advancements, the comments made in 1974 still apply in many ways to the situation today:

> " A technical committee developed a *Manual of Septic Tank Practice* to solve the growing need for temporary use of septic tanks for waste treatment in subdivisions that could not afford central systems immediately. The original committee members felt that the data developed would be adequate for most soils and site conditions to serve from 3 to 5 years. Today, the *Manual of Septic Tank Practice* is used by builders and others to convince rural home buyers that a septic tank system designed in accordance with these standards will give long

> lasting, trouble free service for the 33 year period of the loan. Unfortunately, FmHA has found on numerous occasions that septic tank failures cause a decrease in the value of rural homes; consequently, we discourage the extensive use of septic tanks in rural subdivisions."

The speaker, Mr. Cecil W. Rose, then addressed the issue of ineffective control as follows:

> " In my home state of Virginia there are contractors who joke that it is possible to get any lot to "perk" by paying the County Inspector $50. Because of these and similar occurrences, septic tanks have received a bad name. Studies show that only about 30% of the soils are really suitable for septic tank use. Still, builders want to build septic tanks on every site. In some areas, one lot will percolate, while one adjacent might fail miserably.
>
> It will be necessary to give greater emphasis to honest evaluation of septic tanks and on the use of other on-site treatment systems."

Given the present economic climate, in which new community sewage disposal facilities are not likely to be

built unless financed and operated privately, there will be increased demand for effective on-lot sewage disposal systems. It is hoped that this report will assist in the resolution of conflicts between builders, lenders, and regulatory agencies by contributing to more effective control of the construction of elevated sand mounds in Pennsylvania.

The Role of the Sewage Enforcement Officer

The Pennsylvania Sewage Facilities Act of 1966 (19, 20) requires all municipalities to employ a Sewage Enforcement Officer (SEO). The SEO's primary responsibility is to administer the inspection and enforcement provisions of the Act as they pertain to individual on-site sewage disposal systems. In many cases, however, the SEO also assists the municipality in the administration of the portions of the Act pertaining to periodic updates of the master plan for sewage facilities in the municipality.

The SEO is an employee of the municipality and is not under the direct control of the Pennsylvania Department of Environmental Resources (DER). DER establishes the standards which are enforced by the SEO and provides for training and certification of all SEO's. DER does have some control over the enforcement of the Act at the municipal level because it can revoke the certification of an SEO if there is evidence that the individual is not enforcing the regulations properly

(16, 20, 21).

There are approximately 2,500 municipalities in the Commonwealth of Pennsylvania which are served by approximately 700 certified SEO's. There are many more certified SEO's in the Commonwealth, but most of them are not actively engaged in practice. The municipal SEO may be a full time employee of the municipality. In most cases, however, he is a part time employee working on a reimbursible basis for several municipalities. Some of the SEO's are private contractors, others are employed by consulting engineering firms who also provide other services under contract to the municipality. The SEO function also may be a collateral duty assigned to a local zoning officer, municipal engineer, or other municipal employee.

Fees for SEO services, such as site evaluations and percolation tests, are established by the municipality and vary widely throughout the Commonwealth. The fee for the basic services described above varies from $70 to $700 depending on the location (32). It is the opinion of the author that the $700 fee for this service may reflect the fact that some municipalities seek to use the Sewage Facilities Act as an exclusionary zoning tool by charging unreasonably high rates for SEO services.

Site Evaluation Procedure.

The builder or other person who desires to install an on-lot sewage disposal system must first contact the SEO and

submit a permit application. The SEO then will advise the applicant when he can visit the site to conduct the site evaluation. In most cases the applicant has some idea about the desired location for the septic tank, dosing tank, and drainage field. In many cases, a complete design will have been prepared by an engineer. The SEO also may provide design assistance in some cases and will review all designs prepared and submitted with the permit application for compliance with the regulations.

Factors Governing Location of the Absorption Area. There are several factors which will govern the location of the proposed drainage field or "absorption area". First of all, the slope cannot exceed 8 percent for installation of an elevated sand mound (19, 21). In addition, the sand mound cannot be located: (1) in a known flood plain area or in an existing drainage way, (2) in areas where rock outcrops exist within the proposed absorption area, (3) over limestone depressions or sinkholes, or (4) over fill material (19). The regulations also specify "isolation distances" which will govern the location of the absorption area. Applicable isolation distances are summarized below (19):

Horizontal Isolation Distances (ft) From Septic Tank To:

Property Lines	10
Easements	10
Right-of Way	10

Occupied Buildings	10
Pools	10
Driveways	10
Water Supply System Suction	50
Water Supply Line Under Pressure	10
Surface Waters	25

Horizontal Isolation Distances (ft) From Mound Perimeter To:

Property Lines	10
Easements	10
Right-of-Way	10
Occupied Buildings	10
Swimming Pools	10
Driveways	10
Water Supply System Suction	100
Water Supply Line Under Pressure	10
Surface Waters	50
Other Active On-Lot Systems	20
Surface Drainageways	10
Mine Subsidence Areas/Bore Holes/Sinkholes	100
Rock Outcrops or Shallow Rock Pinnacles	10
Natural or Manmade Slope Greater Than 25%	10

It is important to note that these isolation distances will be verified on site by the SEO during his inspection. In addition, the eventual occupant of the residence should be aware of the need for maintaining the distances. Installation

of a driveway immediately adjacent to the mound on the downslope side, for example, will result in excessive compaction of the soils and will probably cause the eventual hydraulic failure of the mound. The builder should assume responsibility for providing this information to the owner. This issue is addressed in detail in Chapter 5.

There is no minimum lot size specified by DER for installation of an elevated sand mound system. In some areas, however, large lot sizes are required by the local municipality if such a system is to be installed (12). This type of requirement often is based more on a desire to exclude certain types of high density development than on a need to protect the environment.

Examination of Soil Profiles. Once the site for the drainage field (elevated sand mound in this case) has been identified, the SEO designates the locations for one or more backhoe pits to be excavated. These pits must be located within 10 feet of the proposed drainage field. The excavation must extend to the top of the limiting zone or to a maximum depth of eight (19, 21). In most cases, a depth of five to seven feet will be adequate. The purpose of the backhoe pit is to permit the SEO to examine the soil profile. The SEO will examine the soils and will identify the limiting zone if it exists in the exposed profile. The SEO will be looking for limiting factors such as the existing water table level, the presence of soil mottling (which could be indicative of a seasonally high water table), impermeable

material layers, rock, and other factors which could influence the permeability of the soil. The SEO must be able to identify at least 20 inches of suitable soils above any type of limiting zone before he will issue a permit for an elevated sand mound (19, 21).

In some cases, the appplicant can obtain a rough evaluation of the suitability of a particular soil type for installation of an on-lot sewage disposal system by examining the SCS Soil Survey and Soil Maps for the area in question (12). It should be noted, however, that the information obtained from those sources is general in nature and may not accurately reflect the soil conditions or even the soil type actually encountered on the site. The controlling factor in all cases will be the actual soil profile examined on the site, combined with the results of the percolation test. Many weaknesses with the percolation test procedure have been identified and an extensive research effort has been conducted in an attempt to develop alternative test procedures which more accurately reflect the true hydraulic conductivity of the soils. Revised test procedures, testing instruments, and even computer modeling (30) are being proposed as alternatives to the percolation test, but none of these are being considered by the Pennsylvania Department of Environmental Resources as a replacement for the percolation test.

Percolation Testing. If a limiting zone is not identified, the SEO will direct the applicant to prepare at least six test holes spaced uniformly within the proposed absorption area

(19). The SEO will provide the applicant with detailed instructions for the preparation of the test holes in accordance with the regulations (19). In general, the six to ten inch diameter holes can be dug with a post-hole digger. The depth of the hole should match the depth of the absorption area as identified by the SEO in the soil profile. The bottom and sides of the holes must be scraped with a knife blade to eliminate any smearing of the soils which would interfere with the percolation test. After all loose material is removed from the hole, two inches of fine gravel is placed in the bottom of the hole. The holes then must be pre-soaked in water for 8 to 24 hours. This pre-soaking usually is done overnight so that the percolation test can be conducted by the SEO on the following morning. Pre-soaking involves filling the holes with at least 12 inches of water and allowing it to stand undisturbed for the period specified above.

The percolation test itself is a simple procedure involving the measurement of the rate of drop of the water placed in the test holes. This measurement is an indirect indication of the hydraulic conductivity of the soils which, when combined with the visual analysis of the soil profile, provides a reasonable indication of the capability of the soils to renovate the septic tank effluent. The percolation rate in units of minutes per inch is determined by taking the arithmetic mean of the percolation rates determined for each of the test holes.

The actual test procedure begins with final presoaking of

the holes. The builder should ensure that there is adequate water on hand at the site for the SEO to conduct the test. Final presoaking involves filling the holes to a depth of at least six inches and readjusting to maintain the level of fill every 30 minutes for one hour (19, 21). The drop in the water level over the last 30 minutes of the final soaking is recorded by the SEO by measuring the drop using a yardstick placed in the hole. If the water drops out of the hole before the 30 minutes have expired, the SEO will conduct percolation test readings at 10 minute intervals. If water remains in the hole after the 30 minutes have expired, the test interval used is 30 minutes long.(19, 21)

The percolation test procedure following the final soaking period begins with refilling of the holes with six or more inches of water over the two inches of gravel at the bottom of the hole. A reference point is established above each hole for use in measuring the distance to the water surface to be read on the yardstick at each test time interval. A minimum of eight readings are taken. Readings must be continued until a stabilized rate of drop has been acheived (a stabilized rate is defined as a difference of 1/4 inch or less between the highest and lowest readings of four consecutive readings) (19). The drop recorded in the final test interval is the one to be used for determining the arithmetic mean percolation rate. If no measurable rate is obtained in a hole, a percolation rate of 240 min/in is assigned to that hole. If no measurable rate is obtained in

three or more holes, the absorption rate is considered to be unsuitable and the permit will be denied.(19, 21)

The range of acceptable percolation rates for elevated sand mound installations is from 3 to 120 min/in. The percolation rate determined in this test is one of the factors needed for design of the absorption area and is discussed in further detail in Chapter 3.

Summary

The regulatory approach used in the Commonwealth of Pennsylvania for control of on-lot sewage disposal places strong emphasis on the evaluation of soil conditions on the proposed site. Enforcement responsibility is delegated to SEO's employed by the local municipalities. The SEO must assume responsibility for ensuring that on-lot sewage disposal systems are well designed, properly constructed, and maintained in good operating condition. Builders must be aware of the role played by the SEO and should become familiar with the site evaluation procedure discussed in this chapter.

Chapter 3

DESIGN

Introduction

The design standards for elevated sand mound beds in Pennsylvania have changed considerably since the early 1970's. The latest standards were adopted in 1983 by amendment to the Pennsylvania Sewage Facilities Act of 1966 (19, 20). The Technical Manual for Sewage Enforcement Officers (21) also was updated in 1983 to reflect the revised standards. It is important to note, however, that DER encouraged the use of the latest design innovations long before the actual legislative action was taken by permitting construction of the mounds as experimental systems (32).

The revised standards which are now in force (19, 20, 21) are based on the results of extensive research conducted over the past decade. The recommendations made in the Petersen study (6) essentially were adopted in their entirety. The new standards also have incorporated many of the GLUMRB recommendations (1) and U.S. EPA standards (4). Research conducted at the University of Wisconsin's Small Scale Waste Management Project also weighed heavily in the design standard revisions (28).

This chapter will address the design and estimating process for elevated sand mound beds for residential use. The design procedure presented in this chapter is a simplified

process which involves the use of tables and worksheets to develop the final design. Tables are set up to cover the ranges of acceptable sizes, flows, dimensions, etc. which are typically found in residential systems. In all cases, design recommendations meet or exceed DER standards. A conservative bias has been built into the tables to ensure that the final product performs as required for the conditions specified. Figure 3.1 illustrates the basic components of the elevated sand mound system used in Pennsylvania.

Design

Each step of the design process described in this chapter first will be presented in general terms, followed by the application of the procedure to an example project. The design process is divided into the following steps:

Step 1 - General Design Considerations

Step 2 - Absorption Area Sizing

Step 3 - Estimating Fill Quantities

Step 4 - Lateral Layout and Design

Step 5 - Dosing Tank and Delivery Pipe Design

The example project is assumed to be located in Central Pennsylvania. The system is to be designed for a four bedroom single family residence. The proposed site for the sewage

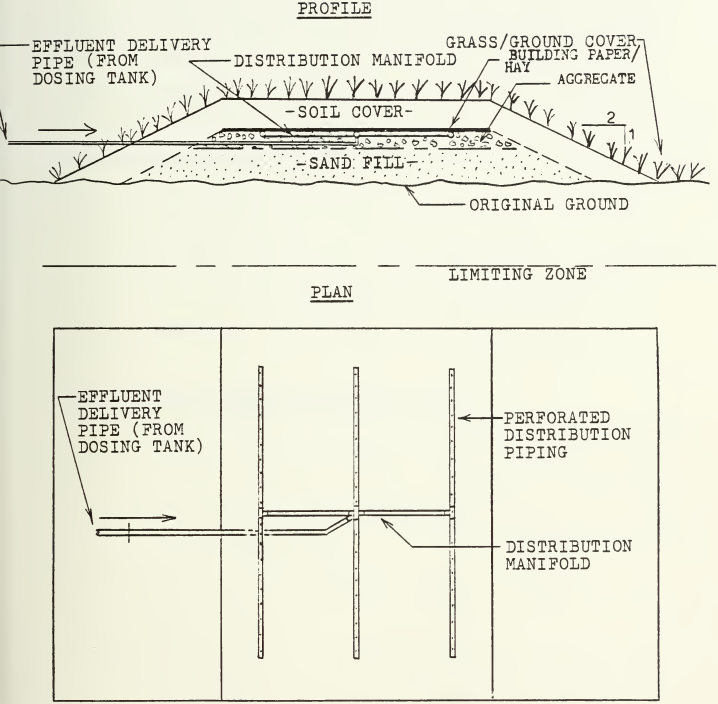


Figure 3.1 The Sand Mound (Basic Components)

disposal system is in a level area at the rear of the residence. The results of the soil profile examination conducted by the SEO indicate that the soil is a sandy loam. Bedrock was not exposed until a depth of six feet had been reached, however, the SEO found evidence of soil mottling at a depth of 24 inches. The SEO interpreted this mottling as evidence of a seasonally high water table, and therefore, designated 24 inches as the depth to the limiting zone. Since the limiting zone was identified at a depth less that 60 inches from the original ground surface, an elevated sand mound is required on this site. Percolation test holes were prepared to a depth of 20 inches within the proposed absorption area site and the average percolation rate was found to be 70 min/in.

Step 1: General Design Considerations.

The use of water saving fixtures in homes with any type of on-lot sewage disposal system is highly recommended and should be considered by the builder when designing the home. In addition, the builder should ensure that only household wastes are piped to the system. Overloading of the treatment tank can result in carry-over of solids from the treatment tank into the absorption area.

The site evaluation process described in Chapter 2 will determine the type of system to be installed. For example, if an absorption area is selected at a location up-slope from the treatment tank/dosing tank location, a mechanical pumping system will be required to force the effluent through the

distribution system. If an absorption area is selected at a location down-slope from the treatment tank/dosing tank, the builder may install either a mechanical pumping system or a siphon system for effluent distribution. Siphon system design depends upon the capabilities of the siphon as specified by the manufacturer, and therefore is not addressed in detail in this report. The design of the delivery piping system, for example, is dependent upon the particular model of siphon selected. It should be noted, however, that all of the design recommendations presented in this chapter, with the exception of pumping system and delivery piping design, are applicable to elevated sand mounds with siphon systems.

The site selection also influences the cost of the system. For example, a site which is up-slope and distant from the dosing tank requires extensive piping and fittings and a larger capacity pump to reach the distribution manifold. The costs of additional excavation, piping and a larger pump can increase the total cost of the system significantly.

Another design consideration which is extremely important when constructing mounds for residential use is the aesthetic appearance of the mound. Appearance is a major factor which influences decisions made by home buyers. A 30' X 60' "pile of dirt" in the middle of the front yard, for instance, may have a negative impact on a potential buyer's decision about a particular home. The best way to avoid this problem is to install a long, narrow mound on a mildly sloping

area so that it can be blended into the existing landscape as much as possible. The long, narrow mound also will enable the builder to reduce the quantities of fill materials required and will permit construction equipment to reach the entire fill area from the up-slope side so that equipment does not compact the critical effluent disposal area on the down-slope side.

In the case of the example project, it is assumed that the builder has installed water saving fixtures throughout the house in order to prevent overloading of the system. Additional assumptions are: (1) the foundation drains and all downspouts are piped separately and do not contribute flow to the treatment system, (2) the site selected for the absorption area is in a nearby wooded area at the rear of the house and (3) a slight uphill grade exists from the proposed location of the dosing tank to the proposed location for the absorption area, therefore, a pumping system will be needed for this site.

Step 2: Absorption Area Sizing.

The tables and figures presented in this chapter will allow the builder to determine the size of the absorption area required for 3, 4 or 5 bedroom single family detached residences. The square-footage requirements are simply a function of the percolation rate (determined by the SEO) and the peak daily sewage flow from the residence. Soil absorption area sizing has been the subject of research at the Pennsylvania State University (26); the results of which generally have been included in the DER standards (20).

DER standards (20) require that the design of the absorption area be based on a minimum flow of 400 gpd for all single family dwellings having three bedrooms or less. The minimum flow is increased by 100 gpd for each bedroom over three.

It should be noted that the "aggregate absorption area" referred to in this chapter and shown in Figure 3.1 is the horizontal (level) surface area of the aggregate (gravel) surrounding the distribution laterals. It is not the base area of the mound. The base area of the mound is considerably larger and will vary with the amount of sand fill required and the slope of the original ground.

The amount of aggregate needed is based on a minimum requirement of 6 inches of gravel below, and 2 inches of gravel above, the distribution laterals. The volume of gravel required is equal to AGGREGATE ABSORPTION AREA X AGGREGATE DEPTH. The aggregate volume has been calculated and entered in the design tables presented in this chapter for use by the builder in preparing estimates.

Design tables have been developed by the writer in order to enable the builder to rapidly design and prepare an estimate for an elevated sand mound system. The data displayed in the tables have been adapted from a series of tables and standards in the Technical Manual for Sewage Enforcement Officers (21). The notes listed below apply to the design tables.

Notes:

(1) Aggregate volumes are based on a 10 inch depth over the entire absorption area (6 inches below laterals, 2 inches for laterals/manifold and a final 2 inch cover layer). The quantities shown include an allowance for waste and settling which may occur during construction.

(2) Dimensions shown are "optimum" for the required area. In general, the narrowest possible mound with a total lateral length of 75 feet or less has been selected. Manifold lengths of 6, 12 and 18 feet are based on a minimum allowable lateral spacing of 6 feet (19, 21). The recommended dimensions shown in the tables also include allowances for the required 2-5 ft. isolation distance from the lateral piping to the edge of the mound (19, 21).

(3) Tables 3.1, 3.2, and 3.3 have been developed for residential construction applications only. THEY CANNOT BE USED FOR DESIGN OF ELEVATED SAND MOUNDS FOR COMMERCIAL, INDUSTRIAL, OR MULTI-FAMILY RESIDENTIAL WASTEWATER DISPOSAL.

(4) Alternative bed dimensions may be substituted as required to fit the site. Aggregate volumes and total lateral lengths remain the same. Alternative lateral configurations may be selected from Figure 3.2 if the recommended long, narrow configurations cannot be adapted to the site. Lateral notation (ie. A, B, C, D...) is the same as that used in the *Technical Manual for Sewage Enforcement Officers*.

Table 3.1 Design Data for ESM Beds

(3 Bedroom SFD Residence)

Avg. Perc. Rate (min/in)	Aggr. Absorp. Area (sf)	Aggr. Vol. (cy)	Aggr. Absorp. Area (ftxft)	Manif. Length (ft)	Total Lateral Length (ft)	Lateral^ Config. (#/type)	Lateral Disch. (gpm)
Less than 3			Unsuitable				
3- 5 *	600	20	10x60	6	108	4/D	15
6-15 *	600	20	10x60	6	108	4/D	15
16-30 *	600	20	10x60	6	108	4/D	15
31-45 *	756	25	12x63	6	108	4/D	15
46-60	888	29	12x74	6	132	4/E	18
61-75	1008	33	14x75	6	132	4/E	18
76-90	1128	36	16x71	12	198	6/E	27
91-105	1230	40	17x73	12@	198	6/E	27
106-120	1332	43	18x74	12@	284	6/E	27
Greater than 120			Unsuitable				

Notes:

* 1/3 reduction in the absorption area size is permitted if an aerobic tank is used (19).

@ Manifold diameter = 2 inches. All others are 1 1/2 inch diameter (19).

^ See Figure 3.2 for lateral configuration details D and E.

(Table developed by writer from standards published in the Technical Manual for Sewage Enforcement Officers.)

Table 3.2 Design Data for ESM Beds

(4 Bedroom SFD Residence)

Avg. Perc. Rate (min/in)	Aggr. Absorp. Area (sf)	Aggr. Vol. (cy)	Aggr. Absorp. Area (ftxft)	Manif. Length (ft)	Total Lateral Length (ft)	Lateral^ Config. (#/type)	Lateral Disch. (gpm)
Less than 3			Unsuitable				
3- 5 *	750	25	10x75	6	132	4/E	18
6-15 *	750	25	10x75	6	132	4/E	18
16-30 *	750	25	10x75	6	132	4/E	18
31-45 *	945	31	13x75	6	132	4/E	18
46-60	1110	36	16x70	12	198	6/E	27
61-75	1260	40	17x75	12@	198	6/E	27
76-90	1410	45	20x71	12@	198	6/E	27
91-105	1538	49	22x70	18@	264	8/E	36
106-120	1665	53	22x76	18@	264	8/E	36
Greater than 120			Unsuitable				

Notes:

* 1/3 reduction in the absorption area size is permitted if an aerobic tank is used (19).

@ Manifold diameter = 2 inches. All others are 1 1/2 inch diameter (19).

^ See Figure 3.2 for lateral configuration detail E.

(Table developed by writer from standards published in the Technical Manual for Sewage Enforcement Officers.)

Table 3.3 Design Data for ESM Beds

(5 Bedroom SFD Residence)

Avg. Perc. Rate (min/in)	Aggr. Absorp. Area (sf)	Aggr. Vol. (cy)	Aggr. Absorp. Area (ftxft)	Manif. Length (ft)	Total Lateral Length (ft)	Lateral Config. (#/type)	Lateral Disch. (gpm)
Less than 3				Unsuitable			
3- 5*	900	29	12x75	6	132	4/E	18
6-15*	900	29	12x75	6	132	4/E	18
16-30*	900	29	12x75	6	132	4/E	18
31-45*	1134	36	16x71	12	198	6/E	27
46-60	1332	43	18x74	12@	198	6/E	27
61-75	1512	48	20x76	12@	198	6/E	27
76-90	1692	54	23x74	18@	264	8/E	36
91-105	1845	59	25x74	18@	264	8/E	36
106-120	1998	63	27x74	18@	264	8/E	36
Greater than 120				Unsuitable			

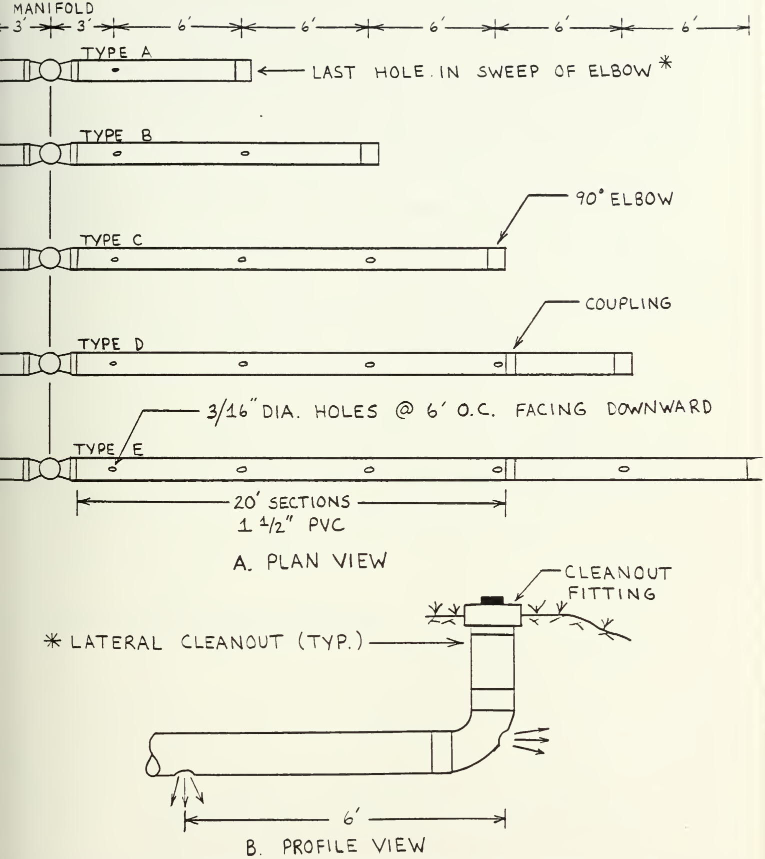
Notes:

* 1/3 reduction in the absorption area size is permitted if an aerobic tank is used (19).

@ Manifold diameter = 2 inches. All others are 1 1/2 inch diameter (19).

^ See Figure 3.2 for lateral configuration detail E.

(Table developed by writer from standards published in the Technical Manual for Sewage Enforcement Officers.)



gure 3.2 Possible Lateral Configurations for Sand Mounds

Source: Pennsylvania Department of Environmental Resources, Technical Manual for Sewage Enforcement Officers, 1983

In the case of the example project, design information is derived from Table 3.2 for a four bedroom home. Entering the table in the first column on the left with the average percolation rate of 70 min/in, the builder would find that an absorption area of 1260 square feet will be required for this site. By continuing to read along the same line, the builder would find that 40 cubic yards of aggregate will be needed to construct an aggregate absorption area with recommended dimensions of 17 ft x 75 ft. A two inch diameter, 12 foot long distribution manifold will be required along with 198 feet of lateral distribution piping. The lateral configuration will consist of six type "E" laterals as described in Figure 3.2., each with an effluent discharge rate of 27 gpm. Figure 3.3 is a design worksheet developed by the writer for use by the builder in recording this information. Figure 3.4 will be used for recording this information and for developing the design for the example project.

Step 3: Fill Material Estimates.

The quantity of sand fill required depends upon the depth to the limiting zone, the slope of the site and the dimensions of the aggregate absorption area. The controlling factors are:

(1) The distance from the bottom of the aggregate absorption area to the limiting zone must be at least 48 inches at all points (19, 21).

. Number of Bedrooms _____.
. Percolation Rate _____ min/in.
. Absorption Area Required _____ sf.
. Absorption Area Dimensions ____ ft X ____ ft.
. Manifold Length _____ ft. Diameter ____ in.
. Lateral Configuration _____. Lateral Length (1½ in PVC) _____ ft.
. Ground Slope (Must be 8% or less) _____ %.
. Depth to Limiting Zone _____ ft. (Must be greater than 20")
. Minimum Depth of Sand Fill Required (48" - LZ Depth) _____ in.
.0. Lateral Discharge Rate _____ gpm.
.1. Delivery Pipe Diameter _____ in. Length _____ ft.
.2. Delivery Pipe Fittings/Equivalent Lengths

Fitting	E.L.		Quantity		Total Length (ft)
A. 90 EL	_____	X	_____	=	_____
B. 45 EL	_____	X	_____	=	_____
C. COUPLING	_____	X	_____	=	_____
D. QUICK DIS.	_____	X	_____	=	_____
E. STD TEE	_____	X	_____	=	_____

TOTAL FITTING LENGTH = A + B + C + D + E = _______ ft.
TOTAL DELIVERY PIPE LENGTH = Fitting Length + Pipe Length = _____ ft.
.3. Delivery Pipe Friction Loss = ______ ft/100 ft. X (______ ft)/(100)
= ______ ft.
.4. Dosing Volume (gal.) (1½" = .09 gal/ft, 2" = .16 gal/ft, 3" = .37gal/ft)
A. LATERALS ________ gal/ft. X ______ ft. = ______ gal.
B. MANIFOLD ________ gal/ft. X ______ ft. = ______ gal.
C. DELIVERY PIPE ______ gal/ft. X ______ ft. = ______ gal.
TOTAL PIPE VOLUME = A + B + C = ______ gal.
REQUIRED DOSE = TOTAL PIPE VOLUME X 5 = ____________ gal.
MINIMUM REQUIRED DOSING TANK VOLUME = DOSE X 2 = __________ gal.
.5. Elevation Change:
A. Elevation Change (Bottom of Dosing Tank to Highest Point at Proposed Mound Site) ______ ft.
B. Required Depth of Sand (9. above) + ______ ft.
C. Aggregate Beneath Manifold + 0.5 ft.
SUBTOTAL (A + B + C) ______ ft.
D. Elevation of Pump Above Tank Bottom - 0.5 ft.
TOTAL ELEVATION CHANGE (C - D) ______ ft.
.6. Total Head (For Pump Selection) = ELEVATION CHANGE + FRICTION LOSS + 3 ft.
= ________ + ________ + 3 = ________ ft.
(15.) (13.)

FRICTION LOSS (ft/100ft)

GPM	1½	2	3	4
15	1.41	.51	.07	---
17	1.86	.63	.09	---
19	2.28	.78	.11	---
20	2.44	.86	.12	.03
25	3.43	1.28	.18	.04
30	5.17	1.80	.25	.06
35	6.91	2.40	.33	.08
40	8.83	3.10	.43	.10
45	10.90	3.85	.54	.13

* EQUIVALENT LENGTHS (ft)

FITTING	1½	2	3	4
90 EL	4.73	5.55	8.23	10.8
45 EL	2.01	2.58	3.84	5.03
STD TEE	8.62	11.1	16.5	21.6
COUPLING/ QUICK DIS	1.05	1.35	2.01	2.64

Figure 3.3 Design Worksheet

1. Number of Bedrooms 4.
2. Percolation Rate 70 min/in.
3. Absorption Area Required 1260 sf.
4. Absorption Area Dimensions 17 ft X 75 ft.
5. Manifold Length 12 ft. Diameter 2 in.
6. Lateral Configuration 6/E. Lateral Length (1½ in PVC) 198 ft.
7. Ground Slope (Must be 8% or less) LEVEL %.
8. Depth to Limiting Zone 2 ft. (Must be greater than 20")
9. Minimum Depth of Sand Fill Required (48" - LZ Depth) 24 in.
10. Lateral Discharge Rate 27 gpm.
11. Delivery Pipe Diameter 3 in. Length 75 ft.
12. Delivery Pipe Fittings/Equivalent Lengths

Fitting	E.L.		Quantity		Total Length (ft)
A. 90 EL	8.23	X	2	=	16.46
B. 45 EL	3.84	X	1	=	3.84
C. COUPLING	2.01	X	4	=	8.04
D. QUICK DIS.	2.01	X	1	=	2.01
E. STD TEE	16.5	X	1	=	16.50

TOTAL FITTING LENGTH = A + B + C + D + E = 46.85 ft.
TOTAL DELIVERY PIPE LENGTH = Fitting Length + Pipe Length = 121.85 ft.

13. Delivery Pipe Friction Loss = 121.85 ft/100 ft. X (0.21 ft)/(100)
= 0.26 ft.

14. Dosing Volume (gal.) (1½" = .09 gal/ft, 2" = .16 gal/ft, 3" = .37 gal/ft)
A. LATERALS .09 gal/ft. X 198 ft. = 17.82 gal.
B. MANIFOLD .16 gal/ft. X 12 ft. = 1.92 gal.
C. DELIVERY PIPE .37 gal/ft. X 75 ft. = 27.75 gal.
TOTAL PIPE VOLUME = A + B + C = 47.49 gal.
REQUIRED DOSE = TOTAL PIPE VOLUME X 5 = 237.5 gal.
MINIMUM REQUIRED DOSING TANK VOLUME = DOSE X 2 = 475 gal.

15. Elevation Change:
A. Elevation Change (Bottom of Dosing Tank to Highest Point at Proposed Mound Site) 8 ft.
B. Required Depth of Sand (9. above) + 2 ft.
C. Aggregate Beneath Manifold + 0.5 ft.
SUBTOTAL (A + B + C) 10.5 ft.
D. Elevation of Pump Above Tank Bottom - 0.5 ft.
TOTAL ELEVATION CHANGE (C - D) 10.0 ft.

16. Total Head (For Pump Selection) = ELEVATION CHANGE + FRICTION LOSS + 3 ft.
$= \underset{(15.)}{10} + \underset{(13.)}{0.26} + 3 = 13.26$ ft.

# FRICTION LOSS (ft/100ft)

GPM	1½	2	3	4
15	1.41	.51	.07	---
17	1.86	.63	.09	---
19	2.28	.78	.11	---
20	2.44	.86	.12	.03
25	3.43	1.28	.18	.04
30	5.17	1.80	.25	.06
35	6.91	2.40	.33	.08
40	8.83	3.10	.43	.10
45	10.90	3.85	.54	.13

* EQUIVALENT LENGTHS (ft)

FITTING	1½	2	3	4
90 EL	4.73	5.55	8.23	10.8
45 EL	2.01	2.58	3.84	5.03
STD TEE	8.62	11.1	16.5	21.6
COUPLING/ QUICK DIS	1.05	1.35	2.01	2.64

Figure 3.4 Design Worksheet (Example)

(2) There must be at least 20 inches of suitable soil above the limiting zone (19, 21).

(3) There must be at least 12 inches of sand fill above the original ground surface. The upper surface of the sand fill must be leveled to +/- 2 inches per 100 feet prior to the placement of the aggregate and the distribution laterals (19, 21).

(4) Side slopes must not be steeper than 2:1 (19, 21).

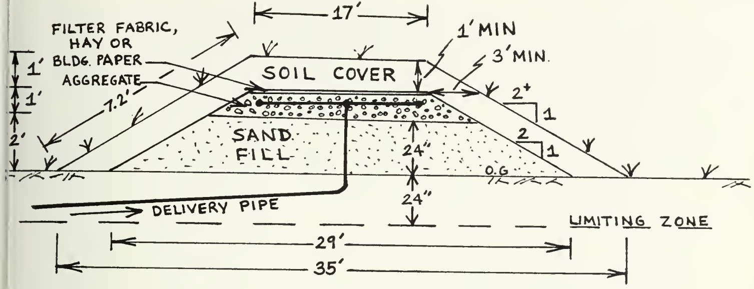
The required quantity of top soil cover depends upon the size of the aggregate absorption area, the ground slope, and the depth of sand and aggregate fill placed in the mound. The controlling factors for estimating the soil cover are:

(1) There must be at least one foot of soil placed above the aggregate absorption area (19, 21).

(2) There must be at least three feet of soil (horizontal) from the outside edge of the aggregate absorption area to the exterior side slope of the mound (19, 21).

(3) The exterior side slopes of the mound should not be steeper than 2:1 and should match the slope of the sand fill.

The builder should prepare a sketch similar to Figure 3.5 in order to estimate the quantities of fill materials required for installation of the mound. Figure 3.5 was developed specifically for the design example, but a similar



A. PROFILE VIEW

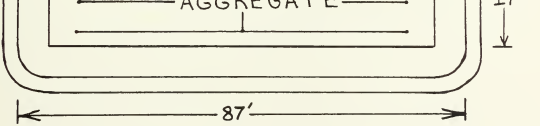
FILL QUANTITIES: (INCLUDES ALLOWANCE FOR WASTE)

SAND – (X-SECT. AREA) x (LENGTH) = $[(2 \times 17) + (2)(2 \times 6 \times \frac{1}{2})] \times 87$

$= 4002$ C.F. ≈ 150 C.Y.

SOIL – (X-SECT. AREA) x (LENGTH) = $[(1 \times 17) + (3 \times 7.2')] \times 93$

$= 3590$ C.F. ≈ 133 C.Y.



B. PLAN VIEW

Figure 3.5 Design Example

sketch can be developed for any other set of design parameters using the information provided up to this point in the chapter. For example, the plan view shown in Figure 3.5 was developed by first laying out the known dimensions for the aggregate absorption area. The depth of the aggregate is one foot, as defined for the design tables, and the depth of the sand fill is two feet, yielding a total depth of fill of 3 feet. The sand fill depth was determined by subtracting the depth to the limiting zone (24 inches in this case) from the required 48 inch distance between the bottom of the aggregate absorption area and the limiting zone. The "footprint" of the sand fill in plan view was then calculated based on the fact that the side slopes will be 2:1 from the top of the aggregate to the intersection with the ground surface. Since the depth of fill was three feet, the additional "footprint" in all directions is six feet. The three foot additional "footprint" shown for the soil cover is based on the minimum requirement for three feet of fill between the outside edge of the aggregate absorption area and the exterior side slope of the mound. The three feet of soil cover is assumed to be constant along the side slope since the soil cover also will be sloped at 2:1. With the three "footprints" established, the mound was dimensioned in plan view as shown.

The profile view in Figure 3.5 was developed by sketching in known information in order to calculate all unknown dimensions. If the sketch is prepared to scale, dimensions can be taken directly from the figure without

performing additional calculations. The depths for each of the fill materials are all known factors, as is the width of the aggregate absorption area. Side slopes are assumed to be 2:1. Given this information, dimensions for the sand and soil "footprints" can be calculated (note that the same dimensions can be taken from the plan view sketch). The only remaining unknown is the length of the exterior side slope, which can be measured directly from the scaled drawing or calculated using simple geometry.

Sand Fill Material Standards. The builder will be required to obtain written certification from the sand supplier that the sand meets the gradation and quality specifications listed below (20). The written certification must be provided to the SEO and the builder with the first delivery to the job site. The sand fill material should not be compacted in any way.

Sieve Size	Maximum % Passing Sieve
3/8"	100
No. 4	90-100
No. 30	20- 60
No.200	0- 15

The clean sand described above can be obtained in virtually all areas of the state. PENNDOT Form 408 lists two sands which meet the specifications listed above (35):

CC Sand Type A (concrete sand)

BC Sand Type B Number 1 (paving sand)

Soil Cover Material Standards. The soil cover material must be good soil, free of fragments larger than 4" in diameter and free of rubble and vegetative matter. The natural topsoil usually can be used for this purpose (21).

If the natural topsoil is poor, it is recommended that good quality topsoil be imported for use as the final six inches of cover material. The good quality top soil will aid in establishing vegetative cover on the mound upon completion of construction. The soil cover material must not be compacted in any way.

Aggregate Material Standards. Laterals must be surrounded by crushed stone or gravel which meets the specification of PENNDOT 3A or 2B Stone (21). The builder should specify this type of material when ordering from the supplier. Written certification of quality and specification compliance is not required by the DER regulations. The builder is encouraged, however, to obtain certification for his own protection in the event the material is found to be unsuitable by the SEO.

Aggregate Bed Cover. The aggregate surface must be covered by a 2 inch thick layer of hay or a single layer

of untreated building paper or filter fabric material prior to placement of the soil fill. The purpose of this material is to prevent the soil from settling into the aggregate. The builder should include this material in the estimate.

Step 4: Lateral Layout.

The steps in the procedure for the layout of the laterals and the distribution manifold within the aggregate absorption area are described below:

(1) Determine the dimensions of the aggregate absorption area, the manifold length, the total lateral length, and the lateral configuration from Table 3.1, 3.2 or 3.3.

(2) Prepare a sketch of the aggregate absorption similar to Figure 3.6 (which was developed specifically for the design example).

(3) Layout the distribution manifold and laterals on the sketch. The manifold should be perpendicular to the long dimension and centered along the short dimension. The delivery pipe connection (from the dosing tank) should be at the center of the manifold.

(4) Check to ensure that isolation distances of not less than 2 feet and not more than 5 feet are provided. Isolation distance is measured from the lateral piping to the borders of the aggregate absorption area.

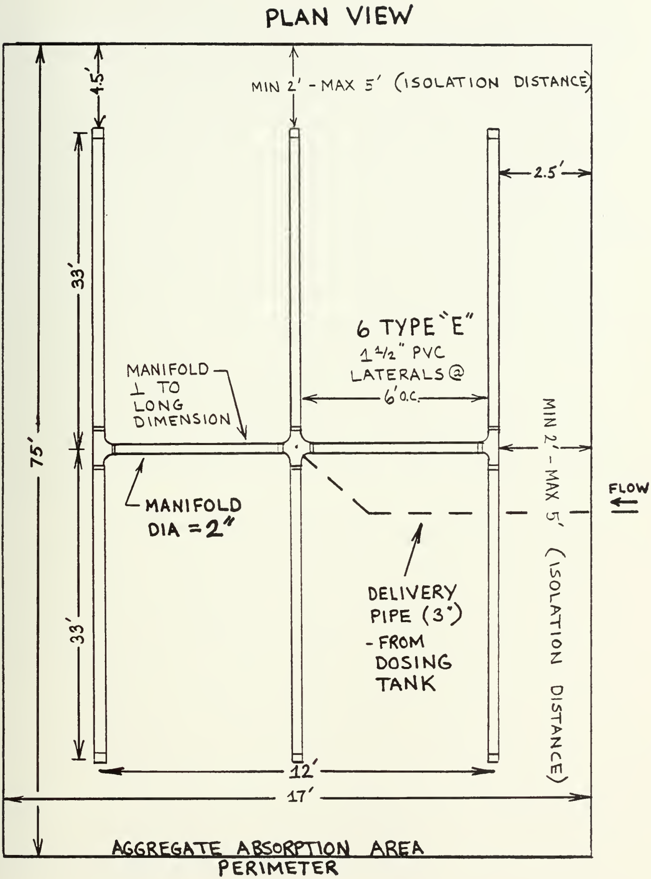

PLAN VIEW
MIN 2' - MAX 5' (ISOLATION DISTANCE)
4.5'
2.5'
33'
6 TYPE "E"
1 1/2" PVC
LATERALS @
6' O.C.
MANIFOLD ⊥ TO LONG DIMENSION
MIN 2' - MAX 5' (ISOLATION DISTANCE)
75'
FLOW
MANIFOLD DIA = 2"
DELIVERY PIPE (3") - FROM DOSING TANK
33'
12'
17'
AGGREGATE ABSORPTION AREA PERIMETER

Figure 3.6 Lateral Layout (Typical)

The laterals must have holes sized and spaced as shown in Figure 3.2. Holes are 3/16" diameter, spaced at 6 ft intervals facing downward. The first hole is drilled at a distance of three feet from the distribution manifold. The last hole is drilled in the 90 degree elbow at the end of the lateral. The elbow connects to a vertical riser for a cleanout at the end of each lateral. The cleanout installation is designed to permit backflushing of the system. All laterals used for pressure distribution in elevated sand mounds must be 1 1/2 inch diameter Schedule 40 PVC (19, 21). Schedule 40 PVC also is required for the distribution manifold, but the diameter can be either 1 1/2 inches or 2 inches depending upon the size of the system (19, 21). (Note that this requirement has been taken into account in the design tables.)

The lateral layout for the design example is shown in Figure 3.6. In this case, a 2 inch diameter, 12 foot long distribution manifold was laid out perpendicular to the long dimension of the mound. Six type "E" laterals then were laid out perpendicular to the distribution manifold. Each lateral has a length of 33 feet as determined from Figure 3.2. Note in this case that the dimensions of the aggregate absorption area have been laid out and that isolation distances of 4.5 feet on the lateral ends and 2.5 feet on the lateral sides have been provided for. These distances are well within the allowable 2-5 foot ranges (19, 21).

Step 3: Dosing Tank and Delivery Pipe Design.

The dosing tank location must be selected carefully to ensure proper operation of the system. The dosing tank must be located so that gravity flow can be maintained from the treatment tank to the dosing tank. In addition, the pump always must be at an elevation lower than the distribution manifold in the mound so that at least a minimal slope is maintained to permit effluent to drain back into the dosing tank after each cycle. Draining of the delivery pipe after each dose will help to prevent clogging and also will prevent freezing of the piping during cold weather.

Figure 3.7 shows the typical arrangement of the components in an elevated sand mound system. The actual configuration will be unique for each site. The builder may want to prepare a sketch similar to Figure 3.7 for use in preparing an estimate.

Elevation and head loss calculations needed for selecting the appropriate pump for the system are performed using the worksheet provided as Figure 3.3. Calculations for the design example are shown in Figure 3.4. The worksheet is used to determine the total head requirement of the pump. Friction losses are determined by converting fittings to equivalent lengths of pipe using the table included in Figure 3.3 and adding those lengths to the actual pipe length. The total equivalent length then is multiplied by a friction factor to obtain the total friction loss. All pipe is assumed to be PVC (Friction

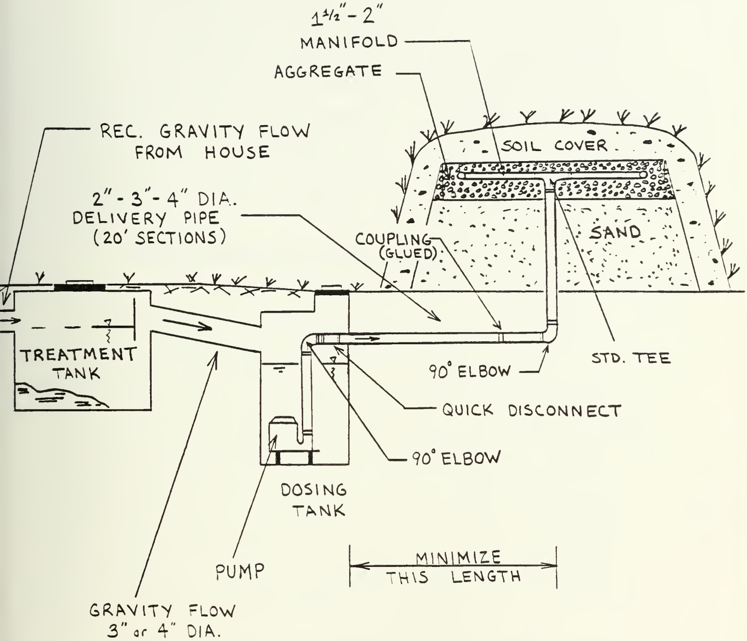


Figure 3.7 Typical Arrangement of a Mound System

Factor C=150). Friction loss in the manifold and laterals is not included in the calculations (20, 21).

The required capacity of the dosing tank is determined by calculating the total volume of liquid held in the delivery piping, manifold and all laterals. The dose volume is equal to five times the internal liquid capacity of the piping or 100 gallons, whichever is greater. The dosing tank storage capacity must be at least twice the dose volume (20, 21).

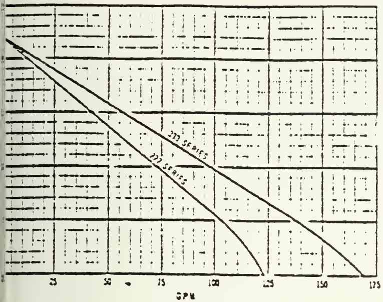
Delivery Pipe Size Determination. The size of the delivery pipe from the pump outlet to the distribution manifold will vary with each installation, but the following are some "rules of thumb" which should be followed. It is generally recommended that a two inch diameter or larger delivery pipe be considered in order to minimize friction loss. Excessive friction loss may result in a requirement for a larger, more expensive pump to overcome the head. In any event, every effort should be made to minimize the length of the delivery pipe and to minimize the number of fittings used. Check valves should not be installed in the delivery piping (21).

Pump Selection. Two design parameters are needed from Figure 3.3: (1) the flow rate in gallons per minute and (2) the total head in feet. The builder must use this information along with pump curves from the manufacturer in order to select a suitable pump for the system. Figure 3.8 displays six examples

Head in Feet	gph	gpm
5	2,700	45
10	1,920	32
15	1,000	17

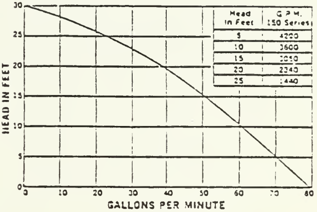
#1

PUMP CAPACITY CURVE



#2

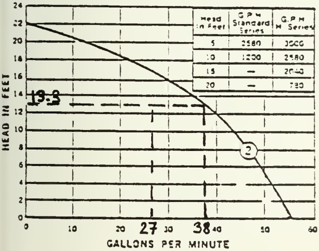
Pump Capacity Curve



Head in Feet	G.P.H. 150 Series
5	4200
10	3600
15	3050
20	2340
25	1440

#3

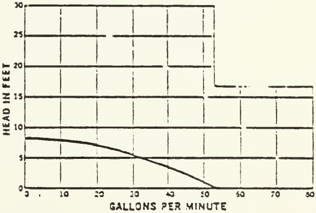
PUMP CAPACITY CURVES



Head in Feet	G.P.H. Standard Series	G.P.H. H Series
5	2580	3000
10	1200	2580
15	—	2040
20	—	750

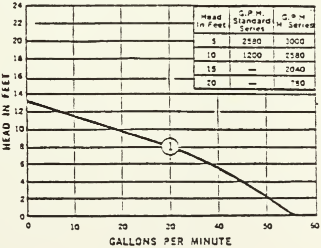
#4

Pump Capacity Curve



#5

PUMP CAPACITY CURVES



Head in Feet	G.P.H. Standard Series	G.P.H. H Series
5	2580	3000
10	1200	2580
15	—	2040
20	—	750

#6

Figure 3.8 Pump Capacity Curves (Examples)

Source: Pennsylvania Department of Environmental Resources, Technical Manual for Sewage Enforcement Officers, 1983.

of manufacturer's pump curves (21). A copy of the pump curve for the pump selected must accompany the permit application submitted to the SEO (20, 21).

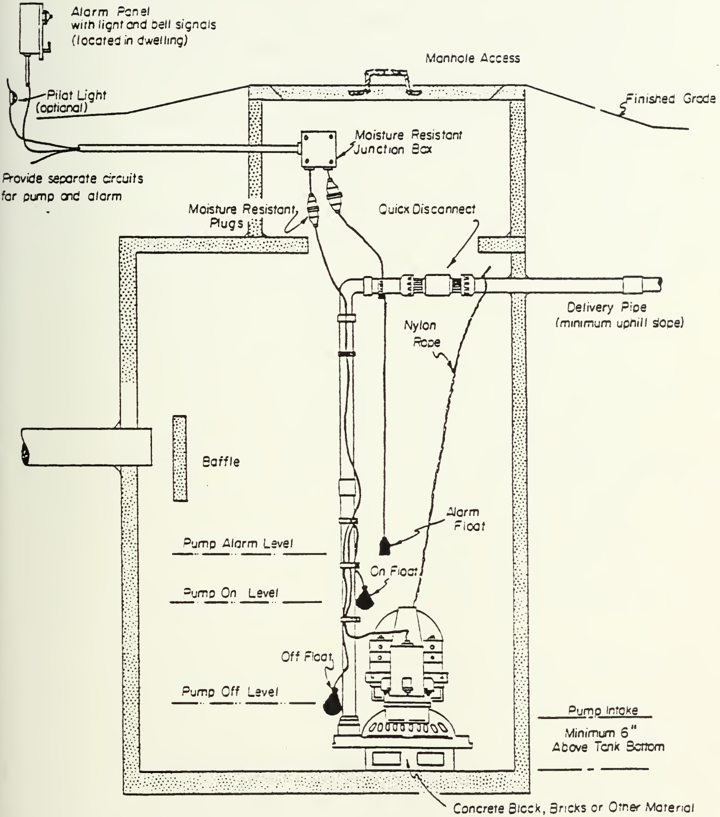
Pumps must be fully submersible. Grinder pumps are not necessary since all solids are retained in the treatment tank. Basement sump pumps or "column pumps" with float switches and unprotected motors are unacceptable (21). The builder should ensure that the pump and all of the associated wiring, controls, piping and fittings are resistant to the highly corrosive atmosphere in the dosing tank. The builder should be particularly careful when selecting fastners to be used inside the tank. Stainless steel and plastic are examples of corrosion resistant materials suitable for use in the tank.

Dosing Tank. Dosing tanks are subject to the same construction standards as those used for septic tanks. In fact, many builders eliminate the problem of custom designing and building a dosing tank by using a pre-fabricated septic tank with a manhole extension as the dosing tank. As long as the tank is large enough to hold the required quantity of effluent (double the design dose), there is no problem with adapting a septic tank to this use. Pre-fabricated concrete tanks in various sizes and shapes are available commercially. As a general rule, the tank should have a depth of at least 5 feet, a minimum width or diameter of at least 3 feet and a storage capacity of at least 250 gallons (The actual

capacity is governed by the distribution system size as discussed below.)

The dosing tank also must have a manhole opening of at least 24 inches in diameter or 20 inches square to permit removal of the pump for servicing. The manhole must extend to the final finished grade. Manhole covers must prevent escape of odors or entry of surface water and must be secured by bolts, a locking mechanism, or have sufficient weight to render them child-proof (21). Figure 3.9 illustrates a typical dosing tank configuration. It also illustrates some of the other design requirements associated with the pump and its' controls. The pump outlet line must be fitted with a quick disconnect fitting located as close as possible to the manhole access so that it can be reached easily. The pump itself must be elevated from the bottom of the tank to avoid suction of any solids which may have been carried over from the septic tank. The builder should place the pump on bricks, blocks or a concrete base at least 6 inches high in order to meet this requirement. The base should not restrict flow to the suction side of the pump in any way. The pump should not be suspended from the top of the tank by chains, straps or other types of hangers and it should be supported sufficiently at the base to prevent excessive strain on the outlet piping (21).

All electrical connections (boxes, splices, plugs, etc.) must be moisture resistant and should be located as



igure 3.9 Typical Dosing Tank

Source: Pennsylvania Department of Environmental Resources, Technical Manual for Sewage Enforcement Officers, 1983.

high up in the tank as possible to avoid contact with the liquid. The wiring shown in Figure 3.8 is strapped to the delivery pipe to prevent the floats from slipping out of position or becoming entangled. Plastic hose clamps or plastic straps are recommended for this application because metal materials tend to corrode and also may damage the insulation on the wiring. (Note: The builder also should consider the float configuration when selecting the tank size so that there is sufficient room for installation). The SEO will inspect all of the wiring to ensure that it is moisture resistant and that it is sufficient for handling the electrical load of the pump, controls, and alarms. In addition, he should verify that all switches or floats have the same amperage and voltage ratings as the pump (21).

Controls. There are several types of pump control systems available. The most common type uses mercury level switches enclosed in polyethylene floats to control pump and alarm functions. This type of system can be adapted easily to any size or shape of tank and is compatible with most of the pumps which are suitable for residential use.

The pump must have a control and alarm system installed which can be adjusted to provide the proper volume dose to the mound. The alarm is designed to alert the owner to any malfunction which has prevented the pump from delivering the dose. As shown in Figure 3.8, the alarm float is located a few inches above the pump-on level. The float will activate an alarm panel with light and bell signals which are located

inside the dwelling. The alarm system and the pump system must be provided with separate breakers or fuses so that a short in the pump does not deactivate the alarm. It is recommended that all wiring from the dwelling to the dosing tank be encased in conduit for added protection.

The other two floats shown in Figure 3.9 are the pump-on float and the pump-off float. The pump-off float should be set at an elevation a few inches above the suction intake. The pump-on float should be set at an elevation so that the volume contained in the dosing tank between the pump-off level and the pump-on level is equal to the required dose. The pump-on level varies with the shape of the dosing tank used.

The easiest way to calculate the required elevation of the pump-on float from the tank bottom is to determine the number of gallons per inch (GPI) of elevation in the tank as shown below. The required dose used in the calculations below is equal to five times the internal volume of the distribution piping or 100 gallons, whichever is greater (19, 21). The formulae shown below are from the Technical Manual for Sewage Enforcement Officers (21). The builder should include this information as a part of the design submitted to the SEO for review. The builder is responsible for installing the control and alarm floats at the proper elevations specified in the design. The SEO should verify that the pump controls have been set for the proper dosing volume and that the storage capacity of the dosing tank is equal to at least twice

the required dose volume.

For Circular Tanks:

(EQN 3.1) $$\text{GPI} = [\text{DIAMETER (in)} \times \text{DIAMETER(in)}] / 292.5$$

(EQN 3.2) $$\text{ON-FLOAT ELEV. (in)} = [\text{REQUIRED DOSE (gal)} / \text{GPI}] + \text{OFF FLOAT ELEV. (in)}$$

For Square or Rectanglular Tanks:

(EQN 3.3) $$\text{GPI} = [\text{WIDTH (in)} \times \text{LENGTH (in)}] / 231$$

(EQN 3.4) $$\text{ON FLOAT ELEV. (in)} = [\text{REQUIRED DOSE (gal)} / \text{GPI}] + \text{OFF FLOAT ELEV. (in)}$$

Determining Storage Capacity:

(EQN 3.5) $$\text{DEPTH (in)} \times \text{GPI} = \text{STORAGE CAPACITY (gal.)}$$

Design Example. The remainder of the design worksheet for the example project can be completed using the information provided in this section (see Figure 3.4).

(1) Delivery Pipe Friction Loss. A 3 inch diameter, 75 foot long delivery pipe will be assumed for the design example. Assume that the following fittings were needed to connect the pump with the distribution manifold using the shortest

possible route:.

90 EL (2 EA) 45 EL (1 EA) STANDARD TEE (1 EA)
COUPLING (4 EA) QUICK DISCONNECT (1 EA)

Equivalent lengths for all fittings are found in the table at the bottom of the worksheet and then are entered as shown in Figure 3.4 to determine the total delivery pipe length (121.85 ft). This information then is used to calculate the total friction loss from the dosing tank to the manifold (0.26 ft).

(2) Dosing Volume. The required dosing volume is determined by adding up the effluent volumes contained in the laterals, the manifold, and the delivery pipe (47.49 gal). The total effluent volume in the piping then is multiplied by a factor of five to establish the required dose (237.5 gal). The minimum required dosing tank volume is twice the required dose (475 gal).

(3) Total Head. The elevation change from the bottom of the dosing tank to the highest point in the piping system at the mound site is assumed to be + 8 FT. The total elevation change then is calculated as shown in Figure 3.4 (10 ft). Total required head then is calculated as shown in the worksheet (13.26 ft).

(4) Pump Selection. Once the Total Head (13.26 ft) and the required flow rate (27 gpm) are known, manufacturer's pump curves such as those shown in Figure 3.8 may be consulted in order to select the appropriate pump. In this case, Pump #4 best meets the requirements for this system since it most closely matches the head and flow rate requirements specified for this system.

(5) Control Float Elevations. Assuming that a 48 inch diameter

dosing tank will be used and that the pump-off float is to be set at an elevation 10 inches from the tank bottom, the elevation of the pump-on float above the tank botton is found to be 40 inches as illustrated below: (Note: For control sytems other than those employing floating mercury level switches, consult the manufacturer's manual to determine the procedure for establishing liquid level settings.)

(EQN 3.1) (48 X 48)/292.5 = 8 gallons per inch

(EQN 3.2) (237.5/8) + 10 = 40 in

Summary

The information provided in this chapter should enable the builder to rapidly design elevated sand mound systems for single family residences. The use of the five step procedure outlined in this chapter and illustrated in the design example will yield a conservative design which meets or exceeds the DER design standards (19). It is recommended that the builder expand upon the information generated using this design procedure by developing detailed drawings and specifications for use by field construction personnel.

CHAPTER 4

CONSTRUCTION

Introduction

Effective construction of elevated sand mounds occurs when the efforts of the owner, designer, SEO, and the builder have been coordinated properly. Planning is the keystone function which leads to the installation of systems which will function properly for many years.

It has become apparent that one of the reasons for the unreasonably high failure rate of mound systems examined in the Petersen study (6, 23) is that there has been a general lack of communication between the parties involved in the construction process. Experienced builders are becoming increasingly aware of the need for advance planning and construction quality control, but there are still many builders who are installing systems without regard for the simple precautions which will prevent failure of the system. Sewage Enforcement Officers must devote more attention to those contractors who have failed to recognize the negative environmental impact resulting from faulty installation of a sand mound system. Given the fact that the installing contractors are not required to be licensed or trained in any way, the SEO must assume the burden of responsibility for ensuring that builders comply with the regulations.

In a speech before the Third National Conference on

Individual On-Site Sewage Disposal Systems (15), Mr. G. Maurer, representing the Pennsylvania Department of Environmental Resources, addressed the need for improved enforcement while discussing the number of mound system failures in the Commonwealth. He reported:

> "In every case...the malfunction was traced to improper enforcement, in that a system was permitted which did not conform to the design standards, was not installed properly, or was improperly maintained."

Clearly, DER holds the SEO responsible for ensuring compliance with the regulations before, during, and after construction. The quality assurance role of the SEO during construction will be addressed in this chapter.

The builder, on the other hand, must assume responsibility for communicating information concerning the operation and maintenance of the system to the owner. The builder's role cannot end upon completion of construction if a reliable system is the desired end product. In the same speech discussed above (15), the lack of builder/owner communication also was addressed:

> "Rumor even has it that an uninformed individual attempted to remove that pile of topsoil, that the builder so nicely left behind, only to find that it was his sewage system."

The point here is that the builder's role in producing a quality product which complies with DER standards includes construction quality control, as discussed in this chapter, as well as education of the eventual users of the system. The process of communicating operation and maintenance information to the owner is addressed in Chapter 5.

The purpose of this chapter is to provide the builder with specific recommendations for construction methods and quality control checks which will result in compliance with the regulations and will contribute to a reduction in the failure rate of elevated sand mound systems in Pennsylvania. Specific topics to be addressed include pre-construction planning, the quality assurance role of the SEO, builder quality control, and recommended construction methods. The information provided in this chapter has been tailored to meet the needs of builders engaged in construction of elevated sand mounds in accordance with DER standards (19). It represents a synthesis of recommendations presented in several design manuals and reports which have addressed this subject (1, 4, 6, 7, 9, 12, 19, 21, 23, 28, 33).

Pre-Construction Planning

The first step taken by the builder in the process of constructing an elevated sand mound system is the development of a pre-construction plan. The pre-plan need not be a formal

written document prepared for each individual installation. Instead, it should be in the form of a checklist which provides a general procedural review designed to ensure that all requirements have been met. Figure 4.1 may be used by the builder for that purpose.

SEO Quality Assurance/ Builder Quality Control

The SEO may visit the site at any time during the construction of the system and may revoke the permit if the installation is not being performed in accordance with the regulations or if the system is not being installed as stated in the permit application (20, 21). In fact, the SEO is responsible for inspection of the system before, during, and after construction and the builder should expect to see him on the site several times. The quality assurance role played by the SEO is unique in that he is there to ensure that an environmentally sound system is installed in accordance with the regulations. The SEO does not represent the owner; a fact which should be communicated to all parties in order to avoid any misunderstanding. The quality assurance role played by the SEO is well defined in the regulations (19, 20). The quality assurance/ quality control checklist provided herein as Figure 4.2 was developed by the writer after a complete

Figure 4.1 - Elevated Sand Mound

Pre- Construction

Checklist

PROJECT: DATE:

ITEM #	CHECKPOINT DESCRIPTION	COMPLETE?
1	Visit site and identify suitable locations for all components. Select 2 or 3 alternative sites for the absorption area.	
2	Submit application and proposed design to the SEO. (The SEO must issue/deny the permit within 7 days.)	
3	Arrange initial site visit with the SEO.	
4	Stake and rope-off the absorption area site plus 10 feet along the down-slope side. DO NOT DISTURB NATURAL SOILS.	
5	Prepare backhoe pit(s) as specified by the SEO. Have a representative on-site during soil profile evaluation.	
6	Prepare 6 or more percolation test holes at locations/depth specified by the SEO. Pre-soak holes overnight. Have a representative on-site during the percolation test. Provide source of	

water for testing.

7 Obtain copy of test results (Form ER-BCE-117) with permit. Modify design to incorporate the SEO's recommendations.

8 Procure estimated quantities of materials:

SAND
AGGREGATE
TOPSOIL
HAY/BLDG PAPER/ FILTER FABRIC
SCH 40 PVC PIPING
PVC PIPE FITTINGS
PRE-CAST SEPTIC TANK(S) (OR OTHER TREATMENT TANK(S))

PRE-CAST DOSING TANK
EXTENSION MANHOLE
WATERPROOFING COMPOUND
*SUBMERSIBLE PUMP
*ALARM SYSTEM
*PUMP CONTROLS
*CONDUIT AND WIRING

* Corrosion resistant materials only.

9 Obtain certification from sand supplier of compliance with PENNDOT FORM 408 specifications for CC Sand Type A or BC Sand Type B Number 1. Provide copy to the SEO with the first delivery.

10 Layout and clear a working area along the up-slope side of the mound.

11 Layout and stake locations of the building sewer, treatment tank(s), dosing tank, and delivery pipe.

Figure 4.2 - Quality Assurance/

Quality Control

Checklist

ITEM #	CHECKPOINT DESCRIPTION	SECT. REF.
	GENERAL ITEMS	
1	Application submitted and signed by the property owner? (FORM ER-BCE-128)	71.41, 71.43
2	Is proposed design included with the application?	71.43
3	Issue/Deny permit within 7 days. (Permit valid for 2 years from issue.)	71.45
4	If permit is denied, applicant may request hearing before local municipality. Request must be in writing and must be filed within 30 days from date of permit denial.	71.47
5	No part of any system may be covered by the builder until the SEO has inspected it and given formal written approval. The SEO must be notified when the system is complete and ready for inspection. The builder may proceed with covering the system if the SEO has not inspected within 72 hours of notification.	71.48

6	Structure is not to be occupied until system is 100% complete and operable.	73.11
7	Ensure that only household wastes are piped to the system. Verify that roof drains and foundation drains are not contributing to the disposal system.	73.11

SITE INVESTIGATION

8	Is backhoe pit located within 10 ft. of the proposed absorption area?	73.14
9	Examine soil profile and record observations on Form ER-BWQ-290.	73.14
10	Specify locations/depth of percolation test holes. Record test results on Form ER-BWQ-290.	73.14

BUILDING SEWER

11	Check for minimum 3" diameter.	73.21
12	Check for cleanout at junction with building drain and at 50' intervals.(If < 4" DIA.)	73.21
13	Check fittings. 90 degree bends are prohibited.	73.21
14	Check minimum slope. (1/4 in./ft.)	73.21
15	Check maximum slope within 10 ft. of treatment tank. (1/8 in./ft.)	
16	Ensure that all joints are watertight.	73.21

Ensure that pipe can withstand imposed loads. (SCH 40 is recommended)

17 Ensure that sewer is vented to the main building stack. 73.21

SEPTIC TANK (IF APPLICABLE)

18 Minimum Capacity 900 Gal. 73.31

19 Verify that required capacity has been provided. 73.31

	Design Flow (GPD)	Required Capacity (GAL)
3 Bedrooms or less	400	900
4 Bedrooms	500	1250
5 Bedrooms	600	1400

AEROBIC TREATMENT TANK (IF APPLICABLE)

20 Minimum manufacturer's rated treatment capacity is 400 gpd. 73.32

21 Verify that required capacity has been provided: 73.32

3 Bedrooms or less................400gpd.

4 Bedrooms........................500gpd

5 Bedrooms........................600gpd

22	Verify that the aerobic treatment tank bears the seal of the National Sanitation Foundation, indicating testing and approval under Standard No. 40. (A seal from an agency other than NSF is not satisfactory unless approved by DER.)	73.32
23	If multiple tanks are used, verify that they are connected in parallel and that the tanks have equal capacity and receive equal loading.	73.32
24	Inspect and test audible and visual alarms installed for the aerobic tank.	73.32

DISTRIBUTION SYSTEM

25	Verify gravity flow from treatment tank to dosing tank through min. 3" DIA. pipe. Minimum pipe slope is 1/4 in./ft.	73.41
26	Pressure distribution required for ESMs.	73.41
27	Ensure that all joints are watertight.	73.44
28	Inspect all fittings. Verify that no check valves have been installed	73.44
29	Verify that manifold has been sized properly.	73.44

DOSING TANK

30	Verify that the tank can hold twice the	73.45

	required dose.	
31	Ensure that there is sufficient space for pump installation and proper operation of control floats.	73.45
32	Ensure that manhole extends to final grade.	73.45
33	Ensure that tank and joint with extension manhole have been waterproofed to prevent infiltration of groundwater.	73.45

DOSING PUMP/CONTROLS

34	Verify that pump inlet is at least 6" from tank bottom.	73.46
35	Ensure that quick disconnect fitting has been installed on delivery pipe inside the tank within easy reach of the manhole.	73.46
36	Ensure that pump is not suspended from chains or hangers and that it is not suspended from the delivery pipe.	73.46
37	Inspect and conduct operational test of all controls and alarms. Check float positioning.	73.46
38	Obtain copy of the pump performance curve. Verify that the pump is adequate for the flow and head requirements of the pressure distribution system.	73.46
39	Ensure that all electrical components are	73.46

of the same voltage and amperage rating. Verify that alarm and control systems are on separate circuits.

40 Inspect all components installed in the dosing tank to ensure that they are corrosion resistant. Pay particular attention to hangers and fasteners.

ABSORPTION AREA

41 Obtain certification, with first delivery, that sand meets Penndot Form 408 spec. 73.51

42 Ensure that all vehicles have been kept off the absorption area site. Check for excessive compaction which may have occurred during site clearing. 73.51

43 Ensure that soil moisture conditions are satisfactory for proceeding with construction. 73.51

CONSTRUCTION

44 Verify that ground slope is less than 8%. 73.55

45 Ensure that 48" of satisfactory soil and fill exists above the limiting zone. Also verify that not less than 12" of sand fill has been placed under the aggregate at all points. 73.55

46 Ensure that no fill material has been 73.55

	mixed with the natural soils in the absorption area.	
47	Inspect site clearing work. All trees should be cut off at ground level and stumps should be left in place. All brush should be cut to the ground surface with roots left in place. Surface chisel plowed parallel to the ground contour to a maximum depth of 6".	73.55
48	Verify that rotary tilling was not used to scarify the surface.	73.55
49	Verify that side slopes of sand fill are not steeper than 2:1.	73.55
50	Check sand leveling. Tolerance is +/- 2 inches per 100 feet.	73.55
51	Inspect soil cover material to ensure that max 20% coarse fragments are present with none exceeding 4" DIA.	73.55
52	Verify that side slopes of soil cover are not steeper than 2:1.	73.55
53	Ensure that at least 1' of soil cover has been placed above the aggregate bed and that the soil cover is at least 3' wide at the top of the aggregate.	73.55
54	Ensure that the mound has not been located in a natural drainage path and that all surface runoff has been diverted	73.55

away from the mound site.

55 Inspect landscaping to ensure that the completed mound has been protected adequately from erosion.

review of the DER standards. References to applicable sections of Chapters 71 and 73, (19, 20), are provided.

The checklist is intended to serve as a quality assurance tool for use by the SEO and as a quality control tool for use by the builder. The builder must become familiar with all of the items listed in the checklist in order to ensure that a good quality product, which fully complies with the regulations, will be constructed.

Builders should be aware of the fact that many of the restrictive codes and regulations which govern the industry have been created in response to the irresponsible actions of a small minority of contractors. The enforcement of DER regulations by local municipalities is vigorously pursued in some areas and is lax in others. It is apparent, however, that there could be a move toward more frequent inspection by SEO's as a means of reducing the high failure rate of on-lot sewage disposal systems if the industry cannot solve the problem alone. The only inspection of the system currently required by the regulations is the cover-up inspection which occurs very late in the construction process. Municipalities could, for example, expand the quality assurance role of the SEO to include inspection and signature authorization to proceed after each of the construction phases listed below:

1) Site Clearing/Site Preparation
2) Excavation
3) Sand Fill Placement
4) Mechanical/Electrical Installation

5) System Operational Test (Prior to Backfilling)

6) Post Construction (Landscaping, Drainage, Erosion Control)

Construction Methods

As noted earlier, the low level of contractor expertise in the construction of elevated sand mound systems was identified as a major contributing factor to the high rate of failure experienced with these systems in the past (6, 23). Improvements in design and construction practices have resulted in improved reliability of the systems in recent years (32). This improved reliability is not to say that all of the problems have been solved. In fact, field observations made by the writer indicate that some of the systems are not being installed in accordance with DER regulations. In one of these cases, the observed contractor had installed several pressure dosed systems in the past, so it appears that the problem may be a fundamental lack of information rather than a lack of experience.

In most cases, elevated sand mounds for residential use are not designed in detail and clearly written specifications are not prepared. The lack of such information for use by field construction personnel is probably a major contributing factor leading to the eventual failure of a system. Builders should consider the need to provide an adequate level of training before sending a foreman or a backhoe operator into the field to exercise his best judgement as to how the system should be built.

Significant improvements in the quality of construction of elevated sand mounds can be achieved if the installer works from a detailed design, has a good construction pre-plan, and follows the basic recommendations for construction methods and quality control described in this chapter.

Exclusive Control of the Project

If the assumption is made that some installers lack expertise in the construction of elevated sand mounds, it also can be assumed that the homeowner has the same problem. In some cases, the contractor may be pressured by the homeowner to identify some phase of the job which he can do himself in order to reduce the cost of the system. The homeowner may, for example, want to clear the site of trees and brush. Although this action seems harmless enough, it is unlikely that the homeowner will be aware of the irreparable damage which can be inflicted on the natural soils if the site clearing is not performed properly. A situation such as this was observed on one project where the homeowner assumed responsibility for site clearing and landscaping. The soils were severely compacted by a tractor and the final landscaping provided almost no protection from erosion. It is strongly recommended that all phases of the job be performed by the installing contractor so that effective quality control may be exercised.

Site Preparation.

The first phase of the construction process is the

preparation of the site. This phase includes laying out the locations of all components of the system, clearing the trees and brush, and preparing the soils in the absorption area.

The locations of the absorption area, the dosing tank, treatment tank, delivery pipe, and the building sewer should be clearly staked out or otherwise marked by a knowledgeable individual before any other work begins. The locations of all of these components should be specified in detail in the design. At a minimum, it is absolutely essential that the limits of the absorption area are clearly marked so that the soils in that area are properly protected from compaction by equipment. The soils in the absorption area must not be disrupted in any manner which could affect the natural percolation of treatment tank effluent. It is recommended that the absorption area, as well as the area down-slope of the mound site, be roped-off to ensure that the soils are protected properly. On one site observed by the writer, the four corners of the absorption area were staked, but none of the other features were properly located and marked. The result was that the backhoe operator simply "eyeballed" the locations for the tanks and the sewer lines. The location chosen for the dosing tank was so close to the absorption area that it ended up being completely buried by the soil fill on the side slope of the mound. In addition, the backhoe tracked directly through the absorption area and along the downslope side of the mound site. As an added precaution, it is recommended that the builder spread a six inch thick layer of sand or soil fill over all areas on which equipment will be operating. This

thin layer of fill will act as a "cushion" to protect the underlying natural soils.

Site clearing outside the general vicinity of the absorption area and the adjacent down-slope area may be accomplished using heavy machinery, if so desired. Stumps and rocks may be removed as required. The installer should take care to ensure that all natural drainage up-slope of the mound site is diverted around the sides so that excessive erosion and saturation of the absorption area does not occur. The installer should also ensure that no existing drainageways are blocked by the site clearing operation, thus in effect diverting the flow directly into the mound. This problem was observed on one site where the mound was located adjacent to a natural drainage path which was subsequently blocked by material stockpiles and brush from the site clearing operation. Surface runoff was diverted directly into the mound excavation while the system was under construction.

Site clearing within the absorption area must also be performed properly in order to ensure that the system will function as designed. The critical factor to be remembered in performing this work is that the natural soils should be disturbed as little as possible. Trees should be cut to nearly ground level using a chainsaw and the stumps should be left in place, undisturbed. Brush should be trimmed to the ground surface, but all roots should be left in place. Following removal of trees and brush, the ground surface should be chisel plowed to a depth of not more than six inches. The

ground surface should never be tilled with any type of disc or rotary tilling equipment because the tilling action will cause the soils to smear. The smeared soil surface will disrupt the natural percolation of effluent and could cause the mound to fail. The ground surface should be covered immediately with a thin layer of sand after the chisel plowing has been completed in order to protect the soils from ponding or erosion due to surface runoff from rainfall. Under no circumstances should any vehicles or construction equipment be permitted to track through the absorption area or across the down-slope side of the mound. The compaction of the soils resulting from vehicles or construction equipment may create an impermeable layer under the mound which could result in rapid hydraulic failure of the system.

The contractor must take into account the soil moisture conditions prior to performing any work on the site. It should be apparent that the potential for damage to the natural soils in and around the absorption area is much higher if the soil is moist. The general rule of thumb is that if the soil does not crumble when formed into a ball in the hand, it is too moist and should not be disturbed until it has dried out. The writer observed heavy equipment operating in and around the absorption area on a site which was completely saturated. In this particular case, the excavations for the tanks and sewer lines were completely flooded, yet the contractor installed the sewer lines and backfilled using a wet clay, long before the SEO had performed his final inspection.

Finally, the preparation of the site must include the clearing of sufficient space along the up-slope side of the mound for use as a materials storage and work area. There should be sufficient room allowed for a backhoe to operate without having to roll onto the absorption area. Figure 4.3 illustrates the recommended layout of the construction site for a mound system.

Excavation.

The next phase of the construction process is the excavation required for installation of the treatment tank, dosing tank, and sewer lines. These components should have been laid out as described above so that the excavation can proceed in an orderly fashion using a backhoe. The contractor should be able to consult a design drawing in order to obtain the depths and slopes specified for the sewer lines and should consult the pre-cast tank supplier to obtain the actual dimensions of the treatment tank and the dosing tank. The design should specify the depths at which these tanks are to be placed. The tanks and the sewer lines should be placed on a compacted bed of soil and should not be installed under wet soil conditions. The excavation should not be backfilled until after the SEO has been called to the site for the final "cover-up" inspection. The installer should fill the tanks with a sufficient amount of water to prevent them from floating if the excavation should flood for any reason.

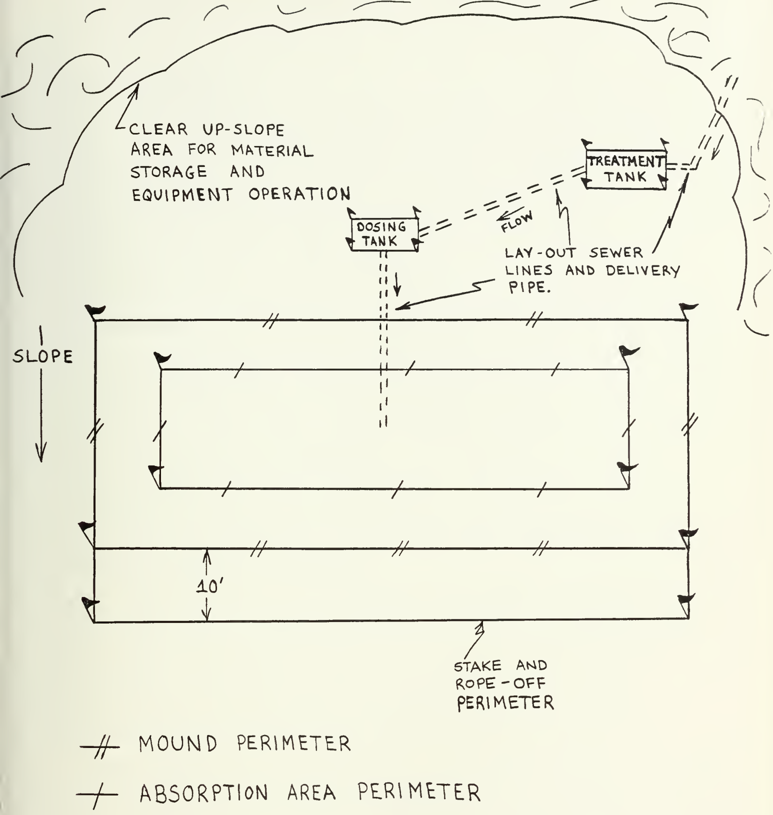

CLEAR UP-SLOPE AREA FOR MATERIAL STORAGE AND EQUIPMENT OPERATION
TREATMENT TANK
DOSING TANK
FLOW
LAY-OUT SEWER LINES AND DELIVERY PIPE.
SLOPE
10'
STAKE AND ROPE-OFF PERIMETER
MOUND PERIMETER
ABSORPTION AREA PERIMETER

Figure 4.3 Site Layout

Fill Placement.

The first layer to be placed in the absorption area is the sand fill. This material should be stockpiled at a convenient location up-slope of the mound and should be spread over the absorption area using a backhoe with sufficient reach to extend across the short dimension of the mound. This procedure should not be a problem if the recommended long, narrow design has been laid out perpendicular to the ground slope. The sand should be leveled to within +/- 2 inches per 100 feet and the side slopes must be no steeper than 2:1. In most cases, these standards cannot be met unless some hand leveling is performed. The installing contractor should ensure that the minimum depth of sand at any point in the mound is 12 inches or the minimum depth specified in the design, whichever is greater.

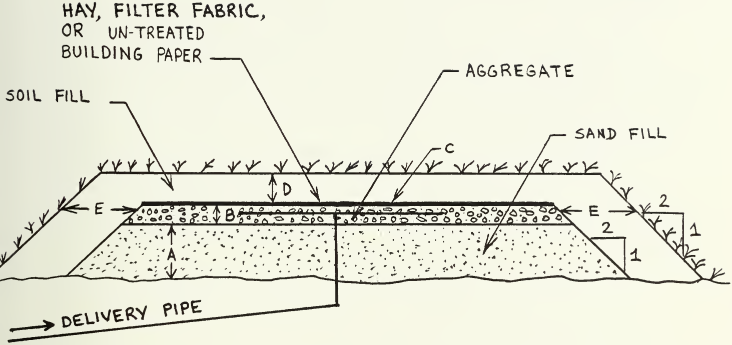
As soon as the sand has been leveled and the depth has been verified, the aggregate bed can be placed using the same procedure followed with the sand. The aggregate should be placed to a uniform depth of 8 inches. The distribution laterals and the manifold will be laid out on top of this level. Following the installation of the distribution laterals and the manifold, additional aggregate must be placed so that the entire lateral system is covered to a depth of at least two inches.

Soil fill should not be placed until after the SEO has conducted his final "cover-up" inspection. The soil may be imported or obtained on the site, but it must be of sufficient

quality to permit the rapid establishment of grass or other ground cover as quickly as possible following the completion of construction. There must be at least one foot of soil fill above the aggregate and there must be at least three feet of soil placed from the edge of the aggregate absorption area to the exterior side slope of the mound. The side slopes must not be steeper than 2:1 and should match the side slopes of the sand fill. Soil fill also should be placed using the backhoe from the up-slope side of the mound, with finishing work being performed by hand as required. Figure 4.4 illustrates the requirements for placement of fill materials.

Pipe Installation.

Pipe sizes should be specified on a design drawing, along with the layout, including required depths and slopes. Schedule 40 PVC is required for the pressure distribution system. Schedule 40 PVC is recommended for all other piping applications associated with elevated sand mounds. If, however, a lightweight sewer pipe is used for the building sewer or the sewer line between the treatment tank and the dosing tank, it is still highly recommended that Schedule 40 piping be installed within ten feet of the tanks in either direction in order to prevent the piping from collapsing or pulling away from the tanks as the surrounding soil begins to settle. The writer observed one contractor installing lightweight sewer pipe in a trench which was partially filled with water. The pipe was not properly supported at any point and the proper slope could not be attained. The excavation



A. 12"(Minimum) or as specified in design. Whichever is greater.

B. 6" (Minimum) below laterals / 2" (Minimum) above laterals.

C. Thin layer (hay) or single thickness (building paper).

D. 1′ (Minimum).

E. 3′ (Minimum).

Figure 4.4 Fill Placement

was backfilled on the same day, prior to inspection by the SEO. There is a high probability that the pipe will be displaced as the surrounding soil begins to settle.

The building sewer and the sewer line between the treatment tank and the dosing tank must have continuous gravity flow. These lines cannot be allowed to sag because solids will accumulate rapidly and flow will become restricted. The minimum allowable slope for these lines is 1/4 in./ft.. The maximum allowable slope within ten feet of the treatment tank is 1/8 in./ft.. These slopes must be verified by the builder prior to backfilling. The minimum diameter permitted for sewer lines is 3 inches. All pipe joints must fit properly to ensure watertight integrity. This requirement will help to prevent the loss of wastewater before it has been properly treated and will also help to keep tree roots and soil from entering the piping system. Finally, pipe installation and backfilling should not be performed under wet conditions because the piping will become displaced after the soils have drained and settled.

All piping installed downstream of the pump will be under pressure each time the dose is delivered to the mound. Each joint, therefore, should be free of burrs, cracks or other imperfections and should be cleaned and glued using the same methods applicable to the installation of pressurized plastic water distribution piping. The delivery pipe from the pump outlet to the distribution manifold must be installed using the minimum possible number of fittings. Check valves must never

be installed in the pressure distribution system. The delivery line must have a minimal uphill slope so that the effluent remaining in the piping can drain back into the tank after the pump has completed its' cycle. The installer should pre-fit the lateral distribution system and delivery piping prior to gluing it in place in order to ensure that all components have been sized and aligned properly. Each lateral should have 3/16" diameter holes drilled in the bottom of the pipe at a point 3 feet from the manifold, then at six foot intervals, with the last hole drilled horizontally in the 90 degree sweep at the end of the lateral. Finally, the builder should install risers from the end sweeps up to the finished grade at the top of the mound, with cleanout fittings on the ends for easy maintenance access.

Tank Installation.

The treatment tank and dosing tank must be set at the proper elevations specified in the design in order to ensure that, (1) gravity flow can be maintained in the building sewer and the sewer between the two tanks and (2) to ensure that the design head between the dosing tank and the distribution manifold in the mound remains unchanged. Installation may be performed by the supplier in some cases. The tanks should be filled with water and should be partially backfilled to prevent them from floating out of position if the water table should rise or the excavation should otherwise become flooded for any reason. If a two piece tank is used or if

an extension manhole is added, the joints must be thoroughly waterproofed to prevent infiltration of ground water and/or leakage of treatment tank effluent. It is also recommended that the tank exterior be waterproofed to minimize infiltration/ leakage at all points. Gaps around inlets and outlets must be filled with mortar or grout to prevent leakage or infiltration at those points.

The dosing tank must have a manhole access which extends to the finished grade. The access manhole must not be covered by the soil fill. The treatment tank also should have an extension installed above the small access port to the inlet baffle in order to permit periodic maintenance to be performed in the event solids become lodged at the end of the building sewer. In one case observed by the writer, the contractor installed an extension manhole above the dosing tank and then defeated the function of the extension manhole by covering it with fill material. In addition, the manhole access was approximately 17" X 17"; too small for maintenance personnel to actually enter the tank.

Dosing Tank Internals.

The proper installation of the piping, wiring, and other equipment located inside the dosing tank is one of the most critical phases of the job. Even if the mound itself has been installed perfectly, the system cannot function if the mechanical and electrical components in the dosing tank fail to operate when required. The installer must recognize that all

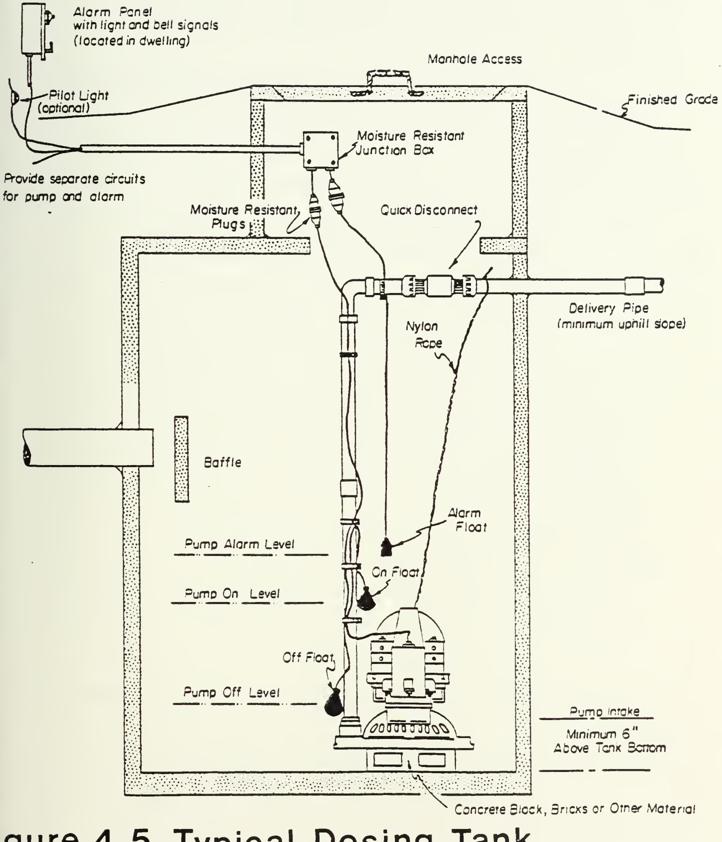
components installed in the dosing tank will be exposed continuously to a moist and highly corrosive atmosphere. When purchasing materials for installation in the dosing tank, consideration must be given to the selection of corrosion resistant materials such as plastics as opposed to metallic components (other than stainless steel). In addition, the pump selected must be fully submersible and must meet or exceed the head and flow rate requirements specified in the design.

It is important to note here that the installation of the mechanical and electrical components for an elevated sand mound system requires skills which are not normally associated with the excavation work which has been described up to this point. The builder must ensure that the personnel assigned to the project have the skills required for installation of pumps, piping, alarms, and control systems. In addition, the SEO must ensure that these components have been properly installed. The SEO should physically inspect all piping, wiring, electrical connections and boxes to ensure that the minimum standards have been met (21). This is particularly important because many rural municipalities have not adopted building codes which would otherwise govern the installation of the equipment.

The first item to be installed in the tank is a concrete block or a few bricks which will serve to elevate the submersible pump suction to a point at least six inches off the bottom of the tank. The pump, with the delivery piping up to and including the attached quick disconnect fitting , is then set in place on top of the bricks. Note that the piping

must be pre-fitted prior to gluing in order to ensure that both ends of the quick disconnect fitting will mate properly when the pump is set into place. The delivery piping should run vertically from the pump outlet, followed by a 90 degree elbow and a quick disconnect fitting near the top of the tank. A nylon line, which must be easily reachable from the manhole access, should be attached to the pump. If the pump should ever require service, it can then be easily removed by disconnecting the delivery piping at the quick disconnect fitting and pulling the pump and the attached piping out through the manhole using the attached nylon line. Figure 4.5 illustrates the typical arrangement of components inside the dosing tank.

After the pump and the distribution piping are in place, the switches which control the on-off cycle of the dosing pump and the high level alarm may be installed. The most common type of switch used is the mercury level switch which usually is encased in a polyethylene float. In order to set the floats at the elevations specified in the design, they should be attached to the vertical portion of the delivery pipe using plastic hose clamps. Excess slack in the wiring should be pulled to the top of the tank in order to prevent the float switches from becoming entangled. Electrical connections made within the dosing tank must be waterproof. All junction boxes installed in the tank must be waterproof and corrosion resistant. It is highly recommended that all wiring splices and connections be made using the "heat shrink" method. All junction boxes and connections located



igure 4.5 Typical Dosing Tank

Source: Pennsylvania Department of Environmental Resources, Technical Manual for Sewage Enforcement Officers, 1983.

inside the tank must be installed high enough in the tank to avoid actual contact with the liquid surface.

Electrical Installation.

The electrical installation required for an elevated sand mound is extremely simple, but it must be performed properly in order to ensure long lasting service. All installed components must be of the same voltage and amperage rating. In most cases, pumps and alarms operate on 120 Volts at 15 - 20 Amps. The alarm system and the pump system must be installed on separate circuits. This requirement is important because the function of the alarm is to alert the owner that a high water level has been reached in the dosing tank. If the pump and the alarm are on the same circuit and the pump fails, causing the breaker to trip, the function of the alarm has been defeated and the owner will not be alerted to the failure. The alarm panel should be installed in the residence served by the system at some convenient location such as in the basement or garage. The wiring from the dosing tank to the breaker panel may be installed by direct burial if a sheathed cable is used, or it may be installed in a buried conduit. It is recommended that the cables be installed in conduit in order to provide added protection. In any event, the local building codes should be checked because they may specify the type of installation required.

The electrical installation observed by the writer on one site failed to pass the SEO's inspection. The electrical

connections and boxes associated with the pump and alarm systems were installed outside the dosing tank in a makeshift wooden box. The electrical components were only partially protected from the weather by the box. In addition, the alarm system was connected to an existing lighting and receptacle circuit via an uncovered interior receptacle installed on the exterior of the house. The alarm panel itself was located in a crawl space where it was also partially exposed to the weather. The SEO made several recommendations for changes, the most important one being that the electrical connections and junction boxes should be installed in the dosing tank, and that all of the components installed in the tank should be waterproof and corrosion resistant. Unfortunately, the contractor simply removed the makeshift wooden box and installed open boxes and unprotected electrical connections inside the extension manhole to the dosing tank. This particular installation is not expected to provide long lasting service.

Final Grading and Landscaping.

Following successful completion of the cover-up inspection by the SEO and after all deficiencies have been corrected, the excavations can be backfilled and the soil cover can be placed on the mound. All ruts and other depressions which could contribute to erosion problems must be filled and leveled. The area surrounding the elevated sand mound should be finish graded to ensure that all surface runoff will be diverted around the sides of the mound. Finally, the

soil surface should be raked to remove rocks, brush and other debris. If the native soils are of such poor quality that vegetative cover cannot be expected to take root, good quality topsoil should be imported for use in establishing vegetation as soon as possible. It is recommended that the entire area be seeded with grass, fertilized, and mulched as soon as possible following completion of construction. Trees and shrubs should not be planted on the side slopes of the mound, particularly those which have extensive shallow root systems.

Summary

Construction of elevated sand mounds will be successful if the builder communicates well with the owner and the SEO, develops a good construction pre-plan, develops adaquate plans and specifications, and exercises effective quality control. The use of the pre-construction and quality assurance/quality control checklists provided in this chapter will assist the builder in meeting the goal of producing a quality end product which complies in full with DER regulations. In addition, employment of the recommended construction methods may help to prevent costly mistakes and in that respect may contribute to lower construction costs as well as improved quality.

CHAPTER 5

OPERATION AND MAINTENANCE

Introduction

The costs incurred by homeowners for the installation of an elevated sand mound system range from as low as $4,000 to as much as $14,000 (32). Given the high cost of these systems, it would seem likely that well informed homeowners would have some interest in ensuring that the the life of the system is extended as long as possible through proper operation and maintenance.

The problem encountered here is that the homeowner, in some cases, it not even remotely aware of (1) where the system is located, (2) how the system works, (3) when to perform maintenance, and (4) how to troubleshoot problems. In many cases, the homeowner may be the third or fourth owner of the home and may not even be aware that the system exists. In other cases, homeowners probably assume that because they were not provided with any turn-over documents (other than the builder's invoice), that the system will take care of itself. In terms of the cost of replacing a failed system, the price of such ignorance can be very high.

Communication

The solutions to the types of problems described above

depend upon the establishment of effective communication between the builder and the homeowner. The homeowner, as a consumer, expects to receive sufficient information to enable him to operate and maintain his sewage disposal system. The builder, on the other hand, should be interested in ensuring that the system has been installed properly so that it will function as designed for many years. The problem here is that in many cases the builder meets his installation objective, but often fails to provide adequate maintenance information to the homeowner. The result in some cases will be a premature failure of the system.

There must be a formal transfer of information between the builder and the homeowner upon completion of the installation. The writer has developed an operation and maintenance fact sheet designed to facilitate this information exchange. The fact sheet includes basic information about how the system functions, the type of equipment installed, recommendations for operation and maintenance, troubleshooting guidance, and a sketch indicatiing the location of each component of the system. The operation and maintenance recommendations provided in the fact sheet represent a synthesis of recommended practices from various references addressing this subject (2, 3, 12, 22, 24, 25).

The builder should fill out the fact sheet (See Figure 5.1) and turn it over to the homeowner upon completion of the installation of the system. In addition, it is recommended that the fact sheet be permanently posted in the home near the

location of the alarm panel or the circuit breaker panel or fuse box. The builder should also turn over all documents received from the pump, control system, and alarm system manufacturers, particularly those needed for warranty registration.

Finally, it is recommended that the builder include the cost of a service contract in the price established for the system. The service contract should provide for inspection of all system components and pumping of the septic tank two years from the date of final installation. The homeowner would be expected to assume full responsibility for periodic maintenance after the first two year service interval.

Figure 5.1 - Elevated Sand Mound System
Operation and Maintenance
Fact Sheet

BUILDER: INSTALLATION DATE:

THIS HOME IS EQUIPPED WITH AN ELEVATED SAND MOUND SEWAGE DISPOSAL SYSTEM. THE COMPONENTS OF THE SYSTEM ARE LOCATED AS SHOWN IN THE SKETCH BELOW.

EQUIPMENT

Treatment Tank Capacity___________ gal

Dosing Tank Capacity___________ gal

Pump Manufacturer______________ Model #____________

Control System Manufacturer_________________ Model #_________

Alarm System Manufacturer___________________ Model #_________

* CONTROL FLOAT POSITIONS

Pump-Off Float_________in   Alarm Float________ in

Pump-On Float_________in   * Elev. From Dosing Tank Bottom

OPERATION

This system operates automatically when functioning normally. The wastewater flows from the house, through the building sewer and into the septic tank or other treatment tank. The treatment tank collects the solids, which will decompose naturally in the tank. The liquid effluent then flows to the dosing tank. An electric submersible pump located inside the dosing tank activates each time a liquid dose of ________ gallons has accumulated in the tank. The liquid is pumped from the dosing tank into a network of distribution piping buried inside the elevated sand mound. The liquid flows out of the distribution piping in the mound and flows downward through the stone and sand fill in the mound. It then penetrates the ground surface and flows into the natural soils.

RECOMMENDATIONS

(1) The septic tank should be pumpeo and the system should be inspected at least once every two years. A service contract has been arranged for the first service interval in ____________(Month/Year). To schedule this service:

Contact: ________________________________

____

Phone: ( ) - -

(2) If an aerobic treatment tank is installed, consult operation and maintenance manual provided by the manufacturer for specific operation and maintenance procedures applicable to your system. A service contract has been arranged to cover the first year of operation of the system. Quarterly inspection of the aerobic treatment tank and all associated mechanical and electrical systems can be arranged by contacting the firm listed below. Inspections should be scheduled during the months listed below: (Month/Year)

1______________________

2______________________

3______________________

4______________________

Contact: ________________________________

____

Phone: ( ) - -

Note: The homeowner should not attempt to correct malfunctions

in the aerobic system. It is strongly recommended that the homeowner contact qualified service personnel for assistance in correcting malfunctions.

(3) Conserve water by using water saving fixtures. Do not connect roof drains, downspouts, foundation drains or any other non-household wastewater drainage to this system.

(4) Use moderation when disposing of grease, household chemicals, and garbage in this system. Do not dispose of plastics or paper products which will not decompose, petroleum products (such as motor oil), or large solids in this system.

(5) Do not use chemical additives designed to clean or disinfect the disposal system. Do not attempt to "flush out" the treatment tank with large volumes of water (this flushing will cause solids to carry over into the dosing tank and into the mound).

(6) Maintain grass cover on and around the elevated sand mound to help control erosion. Do not plant trees or shrubs on the side slopes of the mound.

(7) Do not erect structures or perform any excavation within ten feet of the mound.

(8) Contact the local Sewage Enforcement Officer (SEO) if treatment tank effluent is observed being discharged on the ground surface near the mound.

TROUBLESHOOTING GUIDE

NOTE: The maintenance actions described below can usually be performed by the homeowner. The homeowner should not, however, attempt to enter the treatment tank or the dosing tank, or excavate in the vicinity of the mound. Contact a firm specializing in sewage disposal system installation and maintenance if the problem cannot be solved using the guidance provided below.

PROBLEM	POSSIBLE CAUSES
Dosing Tank High Level Alarm Sounds	1) Fuse blown or breaker tripped.

RESPONSE: Reset the breaker or replace the fuse. If the fuse blows immediately or the breaker cannot be reset, call for service to remove and inspect the pump controls.

2) Pump suction clogged or distribution piping clogged.

RESPONSE: Remove manhole cover on dosing tank. Check for accumulation of solids in the tank, particularly near the pump. If solids are present, call for service and have the dosing tank and treatment tank pumped. Disconnect the delivery piping and remove

the pump from the dosing tank. Flush solids from the pump and the delivery pipe. Back-flush all distribution laterals by removing the cleanout fittings on top of the mound and forcing water back into the dosing tank. Test operate pump motor and controls before reinstalling them in the tank. Install the pump, re-connect the delivery line, and reinstall the cleanout plugs and the dosing tank manhole cover.

3) Defective pump, contols or alarm system.

RESPONSE: Call for service.

Discharge of Treatment Tank Effluent to Ground Surface.

1) Leaks in distribution piping.
2) Unusually high water table or saturation of underlying soils.
3) Hydraulic failure of the mound.

RESPONSE: Call for service and arrange for inspection of the site by the local SEO.

Sewage Backing-Up Into the House

1) Clogged inlet baffle at treatment tank.

RESPONSE: Remove the small access port above the inlet baffle on the treatment tank and check for solids blocking the building sewer. Dislodge solids with a long rod or stick. Note liquid level in the tank. If it is unusually high, call for service and have the tank pumped and the outlet baffle inspected. Remove the manhole cover on the dosing tank and verify that there is free flow between the two tanks.

2) Clogged building sewer or vent stack.

RESPONSE: If flow is slow, check for a clogged vent stack. Insert a sewer tape or sewer routing tool (snake) in the stack to remove any blockage. If this procedure does not solve the problem, and the inlet baffle has been cleared as described above, use the tape or the sewer routing tool to clear the building sewer between the house and the treatment tank. Estimate the distance between the house and the tank inlet before inserting any cleaning device in the line. This procedure will help to avoid entangling the sewer routing tool in the tank. If the line cannot be cleared by this method, call for service.

Summary

In order to meet the objective of reducing the failure rate of elevated sand mound systems in Pennsylvania, the builder must ensure that the homeowner is provided with all of the information necessary for proper operation and maintenance of the system. It has been recommended that the contractor provide the homeowner with a fact sheet as described in this chapter and that the builder turn over to the homeowner all documents provided by equipment manufacturers, particularly those needed for warranty registration. In addition, the builder should schedule the first maintenance checks on the system at a point two years from the installation date. This procedure can be accomplished by including a service contract in the purchase price of the system.

CHAPTER 6

SUMMARY AND CONCLUSIONS

Summary

The Issue.

The need for alternative wastewater disposal systems will grow in the future as funding for large scale community wastewater disposal systems continues to dwindle. Builders in the Commonwealth of Pennsylvania recognize the fact that land development will, therefore, be contingent upon their ability to install effective on-lot sewage disposal systems. The past high failure rate experienced with elevated sand mound installations cannot be tolerated because there will be increasing demand for this type of system as development takes place in areas with marginal soil conditions.

Although recent improvements in the design of elevated sand mounds and improved construction practices have reportedly resulted in a significantly reduced failure rate, there remains a need for increased awareness among builders concerning the negative environmental impact resulting from improper construction of the system. Increased emphasis on quality control and the use of proven materials and construction methods will lead to increased reliability of these systems and will eventually lead to universal acceptance of elevated sand mounds as a viable sewage

disposal alternative by builders, homeowners, lenders, and government agencies.

Responsibility.

The regulatory approach followed in Pennsylvania places strong emphasis on the evaluation of soil conditions and the enforcement of regulations by the SEO at the local level. While the writer does not advocate licensure/certification of builders for installation of these systems, builders must recognize that increased professionalism on their part will lead to significant improvements in construction practices. The builder cannot abdicate responsibility for quality control to the SEO; he must exercise effective control over the project through pre-planning, development of plans and specifications, and quality control inspection on the site. Without effective control by builders, municipalities will eventually be forced to expand the quality assurance role of the SEO to include more frequent mandatory inspections.

Methodology.

Chapters 3 and 4 provide the builder with all of the information needed to design and construct elevated sand mounds which will meet or exceed DER standards. The writer has recommended that the builder expand upon this information by developing detailed plans and specifications for each project. Quality can be improved and costly mistakes can be prevented by following the recommendations provided in

Chapters 3 and 4.

A method of communicating the basic operation and maintenance requirements of the elevated sand mound system to the homeowner was presented in Chapter 5. The builder must recognize that he plays a crucial role in helping to ensure that the system will function as designed for many years.

Conclusions

The high failure rate of elevated sand mound systems in the past was attributed to many factors. The lack of coordination and communication between builders, homeowners and enforcement personnel was apparently one of the underlying causes of the problem. Builders must increase their awareness of the role played by the SEO and the regulations which govern his actions. In addition, improved understanding of design and construction practices will help reduce conficts between builders and enforcement personnel. Finally, a move toward increased professionalism on the part of builders will help to contribute to improved reliability of the finished product.

Areas for Future Research.

Large scale research efforts in the area of on-site sewage disposal are being pursued at several institutions, most notably at the University of Wisconsin and at Purdue

University. The National Sanitation Foundation also is engaged in research in this field. Most of these efforts are directed at the evaluation of existing systems, development of improved systems, and increasing the ability to make reliable judgements concerning site suitability based on soil evaluation.

On a much smaller scale, dealing specifically with on-site sewage disposal Pennsylvania, there are several areas for further research. First, there will be a need to perform field evaluations of the pressure dosed mound systems which have been installed in the Commonwealth in recent years. The purpose of the field evaluation would be to document the failure rate of these systems and investigate the reasons for failure in much the same manner as that followed in the Petersen study. The Pennsylvania Builders Association is conducting an independent evaluation of the pressure dosed systems, but the results have not yet been published.

Second, a comparative analysis of the regulations governing on-site sewage disposal which are in force in various states would be useful. The study could focus on methods used for site evaluation, enforcement, licensure/certification, and inspection. The ultimate objective would be development of a model regulatory approach which could be applied universally to all jurisdictions.

Finally, as a means of integrating available information concerning site evaluation, design, construction and operation/maintenance, it is recommended that future research include the

development of an expert system for on-lot sewage disposal. The expert system should build upon existing design programs which have been developed at Purdue University and at The Pennsylvania State University. The expert system should deal with standards which are unique to Pennsylvania. Ideally, the expert system should be microcomputer based so that it could be widely distributed for use by SEO's, engineers and builders.

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